

AD-A073 051

UNIVERSITY OF SOUTHERN CALIFORNIA LOS ANGELES DEPT 0--ETC F/G 9/2  
SOFTWARE FOR NONLINEAR FILTERING.(U)

JUN 79 R S BUCY, F GHovanlou

F44620-76-C-0085

UNCLASSIFIED

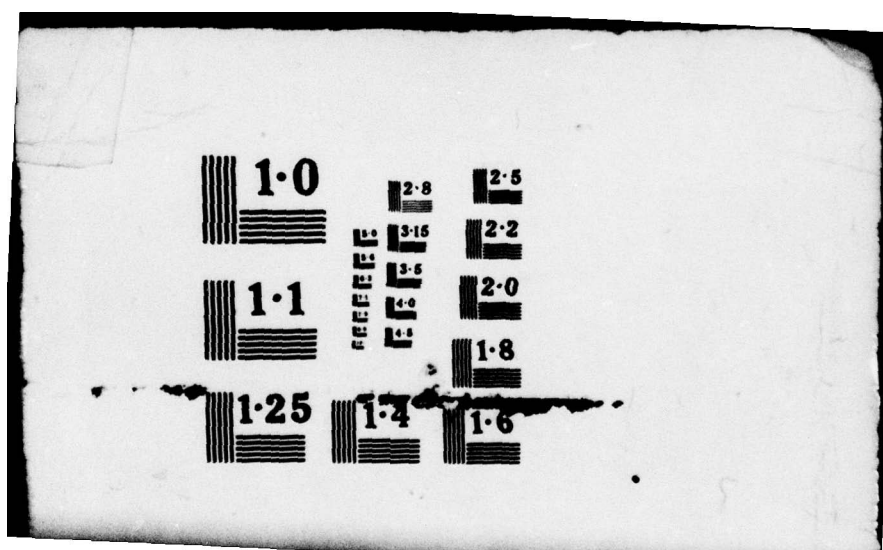
USCAE-53-4514-1787

AFOSR-TR-79-0923

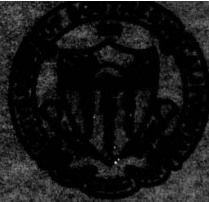
NL

1 OF 2  
AD  
A07305









**UNIVERSITY OF SOUTHERN CALIFORNIA**

**SCHOOL OF ENGINEERING**

**SOFTWARE FOR NONLINEAR FILTERING**

**R.S. Bucy, F. Ghoussien  
A.J. Mattioli, K.D. Senneker**

*Handwritten signature and date 8/14/79*

**DDC FILE COPY**

**79 08 22 046**

**University of Southern California  
Los Angeles, California 90089**

**DEPARTMENT OF AEROSPACE ENGINEERING**

"SOFTWARE FOR NONLINEAR FILTERING"<sup>1</sup>

R.S. Bucy<sup>2</sup>, F. Ghovanlou<sup>2</sup>  
A.J. Mallinckrodt<sup>3</sup>, K.D. Senne<sup>4</sup>

Accession For	
NTIS GMA&I	<input checked="checked" type="checkbox"/>
DDC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/	
Availability Codes	
Dist	Availand/or special
A	

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH (AFSC)  
NOTICE OF TRANSMITTAL TO DDC  
This technical report has been reviewed and is  
approved for public release IAW AFR 190-12 (7b).  
Distribution is unlimited.  
A. D. BLOSE  
Technical Information Officer

- 1 This research was supported in part by the United States Air Force Office of Scientific Research under Contract F44620-76-C-0085, and Grant AFOSR 76-3100.
- 2 University of Southern California, Los Angeles, California.
- 3 Communications Research Laboratory, Santa Ana, California.
- 4 MIT, Lincoln Laboratory, Lexington, Massachusetts.

79 08 22 046

# Table of Contents

## Page Number

	Introduction	1
I	2D Phase Demodulation Software	
1	CDC 6600 Code	2
2	Star 100 Code	12
3	Cray I Code	35
II	3D Phase Demodulation	
1	CDC 7600 Code	40
2	CDC Star - 100	54
3	AP120B Fortran, Assembly Language, Vector Chainer.	71
	References	129



## Introduction

As part of a continuing search for the ideal architecture for performing the computations required to realize a non-linear filter, we have developed software for various machines over the past ten years. A description of the latest software is given in [1], while [2], [3], and [4] are useful for background information on the non-linear filtering problem as well as comments about software efficiencies relevant to various machines.

We started our studies over 10 years ago using the CDC 6600 at the Aerospace Corporation and Kirkland AFB, and continuing at Eglin AFB, see [4]. At the Institute for Advanced Computation, we gained access to the Illiac IV and at ICASE, Nasa Langley, the Star 100, see [2]. Access to the Cray was obtained through Cray Research and later at NCAR. Experiments on the AP120B array processor were possible because of the acquisition of one here at USC used in conjunction with a PDP 11-55.

The purpose of this report is to document the current software, for all these machines. In particular, we have found [2], with the listings of the 6600 and Star Codes, extremely useful in the past, although now these listings are outdated. In particular, the assembly language coding for the AP-120B involved extensive effort over a long time period and should be documented so that others interested in similar problems, can avoid the pain of developing the software from scratch.

## I PHASE DEMODULATION

### I - 1 CDC 6600 Code

The code shown in the following pages evolved through a number of changes. It was most effected by the coding of the Star given in the next section. The philosophy was; carry the two-dimensional density as a single vector of array columns and break up the computation into a large number of loops each small enough so that at least inner loops fit into the stack. Using the CDC FTN Compiler Opt = 2, level 410 operating system this code achieves .63 megaflops.

# A. TWO-DIMENSIONAL CDC-6600 PROGRAM

C <BUCY>STAF.FOR;1 4-NOV-76 10:01:44 EDIT BY BUCY  
PROGRAM CYCLIC(INPUT=129,OUTPUT=129,TAPES=INPUT,TAPE6=OUTPUT)  
DESCRIPTION OF INPUT PARAMETERS

Y1EST,Y2EST - THE EXPECTED VALUE OF INITIAL POSITION  
ALP110 - STEADY STATE ERROR VARIANCE IN DECIBELS  
DELF - THE RATIO OF DELTA TO FILTER TIME CONSTANT  
Q22C - THE CONTINUOUS DRIVING VARIANCE  
NUM1,NUM2 - ARE USED IN CYCLIC AND PROBE ONLY AND COUNT T  
NUMBER OF PARTITION POINTS IN RECTANGULAR GRI  
NO2 - THE TOTAL NUMBER OF POINTS (ESTIMATES) IN EACH SAMP

## DESCRIPTION OF DATA SET

DATA MUST BE PUNCHED IN THE FOLLOWING ORDER:

Y1EST,Y2EST,ALP110,DELF,Q22C,NUM1,NUM2,NO2

ALL REAL PARAMETERS (Y1EST THRU Q22C) HAVE A 10 SPACE FIE  
ALL INTEGER PARAMETERS (NUM1 THRU NO2) HAVE A 5 SPACE FIE  
AND MUST BE RIGHT JUSTIFIED IN THEIR RESPECTIVE FIELDS.

## COMMENTS

THE MAIN FLOW THROUGH THE PROGRAM IS GOVERNED BY KOUNT.  
KOUNT COUNTS THE POINTS IN EACH PATH. A BLOCK IS A SECTI  
OF THE PROGRAM THAT HAS NO TRANSFER IN OR OUT EXCEPT  
THROUGH COMMON.

\*\*\*\*\*

```
COMMON XDAT(130,5),XHAT(2)
COMMON Z(2,2),PBAR(2,2),PK(2,2),AN(2),F(2,2),PDENY(2,2),
*PDUMY2(2,2),PNF(2,2)
LOGICAL LOW,UP
COMMON /RX/ XZZZ(3),XNZ(2)
COMMON /GN/ DZZZ1,JGAUSS,XZZZ(2)
COMMON /PROB/ PI2,PI,ALP110,DELF,Q22C,Y1EST,Y2EST,
1 A11,A22,CONST,DELT,FTC,PIDLT,P110,R11,RX,Q2,Q22
***** START BLOCK 1 *****
2 CONTINUE
JGAUSS=0
Y1EST=0.0
Y2EST=0.0
ALP110=-3.00
DELF=0.1
Q22C=0.01
NUM1=33
NUM2=127
NO2=130
NO3=1
IF(SOP(5)) 2200,5
```

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC



```

PHASE VARIABLES
DO 210 I=1,32
SIGMA(I)=PI*((2.*I-1.)/32.-1.)
COSY(I)=COS(SIGMA(I))
SINY(I)=SIN(SIGMA(I))
S1(I)=COSY(I)/RDEL
210 S2(I)=SINY(I)/RDEL
PHASE RATE VARIABLES
DO 220 I=1,128
220 PSI(I)=PIDEL*((2.*I-1.)/128.-1.)
SETUP THE TRANSFER MATRIX
DO 240 J=1,128
J1=(J-1)*32
J2=(J-1)*33
DO 230 I=1,32
I1=J1+1+MOD(46-(J-1)/4+I,32)
I2=J2+I
230 JNS(I2)=I1
240 JNS(J2+33)=JNS(J2+1)
SETUP THE INTERPOLATION VECTOR
IN(1)=0.875
IN(2)=0.625
IN(3)=0.375
IN(4)=0.125
IN(5)=IN(1)
IN(6)=IN(2)
IN(7)=IN(3)
IN(8)=IN(4)
J=MOD(NTERM,4)
DO 245 I=1,4
245 DELJ(I)=IN(I)
DO 250 I=5,125,4
DELJ(I)=DELJ(I-4)
DELJ(I+1)=DELJ(I-3)
DELJ(I+2)=DELJ(I-2)
250 DELJ(I+3)=DELJ(I-1)
EVALUATE CONVOLUTION TERMS A(I)
DO 280 I=1,NTERM
TEMP=I/128.
TEMP=CONST*TEMP*TEMP
A(I)=0.
IF (TEMP.GT.-47) A(I)=EXP(TEMP)
180 CONTINUE
CONSTRUCT THE A PRIORI DENSITY
CNOBY=1.0/(TWOPI*SQRT(A11*A22))
CL=-0.5/A22
SI=-0.5/A11
DO 290 I=1,32
C9=SIGMA(I)-Y1EST
C7=C9*CP*SI
J1=J
DO 290 J=1,128
J2=J1+I
TEMP=PSI(J)-Y2EST
C0(I2)=EXP(TEMP*TEMP*CL+CP)*CNOBY
90 J1=J1+32
NEXT34

```

THIS PAGE IS BEST QUALITY FRAGMENTABLE  
FROM COPY FURNISHED TO D88

```

J1=NSIZE32
J2=J1
DO 60 I=1,NTERM
J1=J1+32
J2=J2-32
TEMP=A(I)
DO 60 J=1,4096
K1=J1+J
K2=J2+J
60 JN(J)=JN(J)+TEMP*(JNA(K1)+JNA(K2))
C CUMULATE ROW SUMS
DO 90 I=1,32
I1=I
TEMP2=JN(I1)
DO 70 J=1,127
I1=I1+32
70 TEMP2=TEMP2+JN(I1)
PC TPOW(I)=TEMP2
C ACCUMULATE ESTIMATES AND NORMALIZATION CONSTANT
CNORM=TPOW(I)*SN1(I)
SHAT=SINY(I)*CNORM
CHAT=COSY(I)*CNORM
DO 85 J=2,32
TEMP2=TPOW(I)*SN1(I)
SHAT=SHAT+SINY(I)*TEMP2
CHAT=CHAT+COSY(I)*TEMP2
85 CNORM=CNORM+TEMP2
CNORM=1.0/CNORM
SHAT=SHAT*CNORM
CHAT=CHAT*CNORM
C TRANSFER NORMALIZED DENSITY
DO 90 I=1,32
I1=I
TEMP2=SN1(I)*CNORM
DO 90 J=1,127
JN(I1)=TEMP2*JN(I1)
90 I1=I1+32
C TIMEOUT
TIME=SECOND(TI)-T
RETURN
C INITIALIZE SAMPLE PATH BY TRANSFERRING J0 TO JN
100 IF (%C.LE.0) GO TO 200
DO 110 I=1,4096
110 JN(I)=J0(I)
RETURN
C GLOBAL INITIALIZATIONS FOR NONLINEAR FILTER
200 NSIZE=10
NTEPM=64.0*SQR(50.*Q22)/PIDEL+0.5
IF (NTEPM.GT.NSIZE) NTERM=NSIZE
NSIZE32=NSIZE*32
NTEPM32=NTEPM*32
NK2=NSIZE32+1
NJ1=NK2-NTEPM32
NJ2=NSIZE32+4097-NTEPM32
NY1=NSIZE32+4097

```

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC



```

SUBROUTINE NLF(MC,SAMP,Z1,Z2,SHAT,CHAT,TNLF)
INTEGER MC,SAMP
REAL Z1,Z2,SHAT,CHAT,TNLF
INTEGER I,I1,J1,J2,K1,K2,KL,KH,NJ1,NJ2,NK1,NK2,NTERM,
1 NTERM32,NSIZE,NSIZE32
REAL A11,A22,CL,CNORN,CONST,CR,PI,PIDEL,Q22,SI,T,TT,
1 Y1EST,Y2EST,TEMP,TEMP1,TEMP2
REAL IN(9)
REAL TROW(32)
REAL COSY(32),SINY(32),SN1(32),S1(32),S2(32),SIGMA(32)
REAL PSI(128),A(10),DELJ(128)
INTEGER JNS(4224)
REAL JN(4096),JN1(4096),JO(4096),JNA(4756)
COMMON /PROB/ TROW,PI,ALP110,DELF,Q22C,Y1EST,Y2EST,
1 A11,A22,CONST,DEL,FTC,PIDEL,P110,RDEL,RX,QQ,Q22
COMMON /NLFC/ NC,NT,NTERM,NTERM32,S1,S2,SIGMA,PSI,A,COSY,
1 DELJ,JO,JNA,JNS,SINY
EQUIVALENC (JN1(1),JNA(321))
IF (SAMP.LE.0) GO TO 100
SET CLOCK
T=SECOND(T)
EVALUATE SENSOR TERMS
DO 10 I=1,32
10 SN1(I)=EXP(Z1*S1(I)+Z2*S2(I))
FORM THE INTERPOLATED JN AND PUT IN JN1
J1=0
J2=0
DO 30 I=1,128
TEMP=DELJ(I)
DO 20 J=1,32
K1=J1+J
KL=JNS(K1)
KH=JNS(K1+1)
TEMP1=JN(KL)
K2=J2+J
20 JN1(K2)=TEMP1+TEMP*(JN(KH)-TEMP1)
J1=J1+32
30 J2=J2+32
EXPAND INTERPOLATED MATRIX ON BOTH SIDES
J1=NJ1
J2=NJ2
K1=NK1
K2=NK2
DO 40 I=1,NTERM32
JNA(J1)=JNA(J2)
JNA(K1)=JNA(K2)
J1=J1+1
J2=J2+1
K1=K1+1
40 Z2=K2+1
CONVOLUTION
DO 50 I=1,4096
J=I+NSIZE32
50 JN(I)=JNA(J)

```

```

SUBROUTINE GAUSS(JS,SD,XM,X)
DIMENSION NST(2)
COMMON /RN/ N1, N2, HC, T1, T2
COMMON /GH/ THOPT, J, XR(2)
IF (J) 10, 10, 20
10 J=2
THOPT=9.*ATAN(1.)
NST(1)=102943
NST(2)=195617
XR(1)=3ANF(NST,1)
GO TO 35
20 GO TO (30,40), J
30 J=2
XR(1)=BANF(NST,0)
35 XR(2)=BANF(NST,0)
X1=SQRT(ABS(-2.*ALOG(XR(1))))
XR(2)=THOPT*XR(2)
XR(1)=X1*SIN(XR(2))
XR(2)=X1*COS(XR(2))
X=XR(1)*SD*XM
RETURN
40 J=1
X=XR(2)*SD*XM
RETURN
END

```

```

FUNCTION BANF(NS,MODE)
DIMENSION NS(2), NC(2)
COMMON /RN/ N1, N2, XP, T1, T2
DATA N1, N2/244734, 153551/
C      MODE=0 TO CONTINUE, OTHERWISE RESTART WITH
C      INTEGER NUMBER NS(1)*2**13+NS(2)
IF (MODE) 10, 100, 10
10 N1=NS(1)
N2=NS(2)
T1=2.**(-18)
T2=2.**(-36)
HP=2**19
100 DO 200 I=1,2
GO TO (110,120), I
110 K=N2*N2
GO TO 190
120 K=N1*N2+N2*N1+KD
190 KD=K/HP
200 NC(I)=K-KD*XP
N1=NC(2)
N2=NC(1)
XP1=N1
XP2=N2
BANF=XP1*T1+XP2*T2
RETURN
END

```

```

H=NO2-30
SUMP=SUMP/H
SUMC=SUMC/H
XNSAMP=NSAMP
XAA=XNSAMP+1.0
SUMP1=(SUMP+XNSAMP*SUMP1)/XAA
DSUMP1=ALOG10(SUMP1)*10.
WRITE(6,1509)
1508 FORMAT(*0*,5X,*NONLINEAR CYCLIC ESTIMATOR*)
WRITE(6,1511)SUMP1,DSUMP1
1511 FORMAT(*0*,*AVERAGE STATISTICAL VARIANCE =*,1PE13.6,10X,
* *AVERAGE COMPUTED VARIANCE =*,1PE13.6//)
SUMP=0.0
SUMC=0.0
DO 1601 I=31,NO2
  XD=ABS(XDAT(I,1)-XDAT(I,4))
1698 CONTINUE
  IF(XD.GT.PI) GO TO 1699
  GO TO 1700
1699 XD=XD-PI2
  GO TO 1698
1700 SUMP=(XD)**2+SUMP
  SUMC=XDAT(I,5)+SUMC
1601 CONTINUE
SUMP=SUMP/H
SUMC=SUMC/H
SUMP2=(SUMP+XNSAMP*SUMP2)/XAA
DSUMP2=ALOG10(SUMP2)*10.
WRITE(6,1509)
1509 FORMAT(*0*,5X,*RE-LINEARIZED K-B FILTER*)
WRITE(6,1511)SUMP2,DSUMP2
NSAMP=NSAMP+1
IF(ISAMP.EQ.NO3)GO TO 2200
ISAMP=ISAMP+1
GO TO 11
***** END BLOCK 3 *****
1200 WRITE(6,2201)
1201 FORMAT(*0*,40X,*NORMAL COMPLETION*)
STOP
END

```

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC



```

88 X1FF=X1FF-PI2
GO TO 84
89 X1FF=X1FF+PI2
GO TO 84
90 CONTINUE
IF (ABS(CXHAT) .GT. XLIM) LIMNL=LIMNL+1
IF (ABS(X1FF) .GT. XLIM) LINKB=LINKB+1
C ***** PREDICTOR UPDATE *****
XHAT1=XHAT(1) + DELT*XHAT(2)
XHAT2=XHAT(2)
XDAT(KOUNT,4)=XHAT(1)
XDAT(KOUNT,5)=PNF(1,1)
X1MOD=X1
184 CONTINUE
IF(X1MOD.GT.PI) GO TO 188
IF(X1MOD.LT.-PI) GO TO 189
GO TO 190
188 X1MOD=X1MOD-PI2
GO TO 184
189 X1MOD=X1MOD+PI2
GO TO 184
190 CONTINUE
IKBSLP=0
X1F2=ABS(XHAT(1)-X1)
330 IF(X1F2.GT.PI) GO TO 340
GO TO 341
340 CONTINUE
X1F2=X1F2-PI2
IKBSLP = IKBSLP+1
GO TO 339
341 CONTINUE
ERRLF=ABS(X1FF-X1MOD)
ERRNL=ABS(CXHAT-X1MOD)
IF(ERRLF.GT.PI) ERRLF=ABS(ERRLF -PI2)
IF(ERRNL.GT.PI) ERRNL=ABS(ERRNL-PI2)
ERROF=ABS(X1MOD-CXHAT)
WRITE(6,201) KOUNT,XDAT(KOUNT,1),X1MOD,XDAT(KOUNT,2),Z1,Z2,(XDAT
* (KOUNT,I),I=3,5)
201 FORMAT(*0*,I3,1X,1P3E14.6,4X,1P2E14.6,4X,1P3E14.6 /)
IF(KOUNT.EQ.N02) GO TO 505
KOUNT=KOUNT + 1
GO TO 450
505 CONTINUE
SUMP=0.0
SUNC=0.0
DO 1501 I=31,N02
XD=ABS(XDAT(I,1)-XDAT(I,2))
1498 CONTINUE
IF(XD.GT.PI) GO TO 1499
GO TO 1500
1499 XD=XD-PI2
GO TO 1498
1500 SUMP=(XD)**2+SUMP
SUNC=XDAT(I,3)+SUNC
1501 CONTINUE

```

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC

```

DEV3= SQRT(R11)
CALL GAUSS(JSEED,DEV1,Y1EST,X1)
KOUNT=1
XDAT(KOUNT,1)=X1
CALL GAUSS(JSEED,DEV2,Y2EST,X2)
CALL GAUSS(JSEED,DEV3,COS(X1),Z1)
CALL GAUSS(JSEED,DEV3,SIN(X1),Z2)
DEVQ2= SQRT(Q22)
R=511
WRITE(6,1509)
205 FORMAT(*0*,8X,*POSIT.*,5X,*POSIT. MOD 2 PI*,2X,*EST. POSIT.*,9X,
**Z1 AND Z2*,19X,*CYCLIC LOSS*,5X,* K-B EST. AND P11*)
GO TO 470
C ***** END BLOCK 1 *****
C ***** START BLOCK 2 *****
450 CONTINUE
X1=X1 + X2*DELT
XDAT(KOUNT,1)=X1
CALL GAUSS(JSEED,DEVQ2,X2,X2)
CALL GAUSS(JSEED,DEV3,COS(X1),Z1)
CALL GAUSS(JSEED,DEV3,SIN(X1),Z2)
***** RICCATI EQUATION UPDATE *****
PDUMY(1,1)=(P*(PN(1,1)+2.0*PN(1,2)*DELT)-PN(1,2)**2*DELSQ)*DEN
* + PN(2,2)*DELSQ
PDUMY(1,2)=PN(1,2)*(R-PN(1,2)*DELT)*DEN + PN(2,2)*DELT
PDUMY(2,2)=-PN(1,2)**2*DEN + PN(2,2) + Q(2,2)
PN(1,1)=PDUMY(1,1)
PN(1,2)=PDUMY(1,2)
PN(2,2)=PDUMY(2,2)
PN(2,1)=PN(1,2)
DEN = 1.0/(PN(1,1) + R)
***** END BLOCK 2 *****
***** START BLOCK 3 *****
470 CONTINUE
CALL NLF(1,1,Z1,Z2,SHAT,CHAT,TNLF)
WRITE(6,5697) TNLF
5697 FORMAT(F10.5)
CXHAT = ATAN2(SHAT,CHAT)
367 PLOSS=2.0*(1.0-SQRT(SHAT**2+CHAT**2))
XDAT(KOUNT,2)=CXHAT
XDAT(KOUNT,3)=PLOSS
PNF(1,1)=PN(1,1)*R*DEN
PNF(1,2)=PN(1,2)*R*DEN
PNF(2,1)=PNF(1,2)
PNF(2,2)=PN(2,2) - PN(1,2)**2*DEN
***** FILTER UPDATE *****
SINF1=SIN(XHAT1)
COSF1=COS(XHAT1)
XHAT(1)=XHAT1+DEN*(-PN(1,1)*SINF1*Z1+PN(1,1)*COSF1*Z2)
XHAT(2)=XHAT2+DEN*(-PN(1,2)*SINF1*Z1+PN(1,2)*COSF1*Z2)
X1FF=XHAT(1)
34 CONTINUE
IF(X1FF.GT.PI) GO TO 33
IF(Y1FF.LT.-PI) GO TO 39
GO TO 99

```

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC

```

5  CONTINUE
  WRITE(6,651) Y1EST,Y2EST,ALP110,DELF,Q22C,NUM1,NUM2,NO2
651 FORMAT(* *,* CYCLIC INPUT*,4X,5P10.5,3IS)
  P110=10.**(ALP110/10.)
  QQ=Q22C**(.25)
  RX=(P110/(SQRT(2.0)*QQ))**(4.0/3.0)
  FTC=SQRT(2.0)*RX**(.25)/QQ
  DELT=DELF*FTC
  Q22=Q22C*DELT
  P11=RX/DELT
  P220=P110*SQRT(Q22C/RX)
  ISAMP=1
  NSAMP=0
  SUNP1=0.0
  SUNP2=0.0
  CONTINUE
  A11=10.***((ALP110+1.4)/10.)
  A22= P220
  KOUNT=1
  DELSQ=DELT**2
  PI=3.1415926536
  PI2=2.0*PI
  PIDLT=PI/DELT
  CONST=-2.0*PIDLT*PIDLT/Q22
  PINV=1.0/PI
  PI2DLT=2.0*PIDLT
  U1=NUM1
  U2=NUM2
  XLIM=.75*PI
  LIMVL=0
  LIMK3=7
  Q(1,1)=0.0
  Q(2,2)=Q22
  A=DELT*PINV*SQRT(10.0*Q22)
  IA=A+0.5
  IY2="2/PI2DLT*SQRT(50.0*Q22) + .5
  CALL NLF(0,0,Z1,Z2,SHAT,CHAT,TNLF)
11 CALL NLF(1,0,Z1,Z2,SHAT,CHAT,TNLF)
  XHAT(1)=Y1EST
  XHAT(2)=Y2EST
  XHAT1=Y1EST
  XHAT2=Y2EST
  FN(1,1)=A11
  FN(2,2)=A22
  FN(1,2)=0.
  FN(2,1)=0.
  F=311
  DEV1= SQRT(A11)
  DEN=1.0/(FN(1,1)+R)
  F(1,1)=1.0
  F(1,2)=DELT
  F(2,1)=0.
  F(2,2)=1.0
  DEV2= SQRT(A22)

```

THIS PAGE IS BEST QUALITY PRACTICABLE  
FROM COPY FURNISHED TO DDC



## 1 - 2 Star 100 Code

This code was developed by keeping in mind that Star is efficient on long vectors and has a large memory bandwidth, consequently the density was carried as a long vector with extra elements carried in the vector to eliminate the need for modular arithmetic. All operations were viewed as column oriented and assembly listing with loop timing were used to iteratively improve the code. Star Fortran is standard Fortran with added vector instructions such as VGATHER, VSUM, etc. The CDC Star Fortran manual will be helpful in understanding the resulting code. Writing this code and tailoring it to the Star strengths provided much insight into our problem and produced significant improvements on code for the other machines. In particular it is strange that coding for the Illiac had little fallout for other machine coding. The code achieved 16 megaflops.

FORTRAN P1.2 CYCLE 115P2      D=B      SOURCE LISTING      13.39 HRS. 31MAY77

```

00001  PROGRAM MAIN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
      C  SAMPLE PATH VARIABLES
00002      REAL SX1(130),SCHAT(130),SSHAT(130),SX1HATNL(130),SERRNL(130),
      1  TNLF(130),SPLUSSNL(130),SX1HATPL(130),SERRPL(130),SP11PL(130)
      C  CUMULATIVE SAMPLE PATH VARIABLES
00003      REAL CERRNL(130),CESQNL(130),CEVARNL(130),CDBNL(130),CCSNL(130)
00004      REAL CERRPL(130),CESQPL(130),CEVARPL(130),CDBPL(130),CCSPL(130)
      C  MONTE CARLO SUMMARY STATISTICS
00005      REAL XERRNL,XESQNL,XEVARNL,XDBNL,XCSNL,
      1  XERRPL,XESQPL,XEVARPL,XDBPL,XCSPL
      C  SINGLE SAMPLE VARIABLES
00006      REAL CHAT,SHAT,X1HAT,P11,X1,Z1,Z2
      C  CONSTANTS
00007      REAL CS(130),DBEPS,EPS(130),TWOPI,ZERO(130),ONE(130),PI2(130)
      C  WORKING VARIABLES
00008      INTEGER I,J,K,L
00009      REAL T,TEMP(130)
00010      LOGICAL PATH,CUMPATH
00011      BIT BT(130)
      C  PROBLEM SETUP VARIABLES
00012      REAL ALP110,DEL,F,Q22C,Y1EST,Y2EST
00013      INTEGER NMC,NSAMP,MD,ND
      C  DERIVED PROBLEM CONSTANTS
00014      REAL A11,A22,CONST,DEL,FTC,PI,PIDEL,P110,RDEL,RX,QQ,Q22
      C  PROBLEM COMMON
00015      COMMON /PROB/ TWOPI,PI,ALP110,DEL,F,Q22C,Y1EST,Y2EST,A11,A22,
      1  CONST,DEL,FTC,PIDEL,P110,RDEL,RX,QQ,Q22,MD,ND
      C
      C
00016      WRITE(6,991)
00017      991  FORMAT('  FILT2NN, VERSION 4-22')
      C  SET PRINTOUT CONTROL
00018      PATH=.TRUE.
00019      CUMPATH=.TRUE.
      C  READ INPUT PARAMETERS
00020      10  READ (5,5000,END=5000) Y1EST,Y2EST,ALP110,DEL,F,Q22C,NMC,NSAMP,MD
00021      5000  FORMAT(5E10.4,3I5)
      C  COMPUTE THE CONSTANTS
00022      MD=(MD/2)*2
00023      IF (MD.LT.20) MD=32
00024      IF (MD.GT.64) MD=32
00025      ND=4*MD
00026      PI=4.0*ATAN(1.0)
00027      TWOPI=2.0*PI
00028      P110=10.**(ALP110/10.)
  
```



```

00029      QQ=Q22C**(.25)
00030      RX=(P110/(SQRT(2.0)*QQ))**(4.0/3.0)
00031      FTC=SQRT(2.0)*RX**(.25)/QQ
00032      DEL=DELF*FTC
00033      Q22=Q22C*DEL
00034      PDEL=PI/DEL
00035      RDEL=RX/DEL
00036      A11=10.0**((ALP110+1.4)/10.)
00037      A22=2.0*P110/(FTC*FTC)
00038      CONST=-2.0*PDEL*PDEL/Q22
00039      CS(1;130)=0.75*PI
00040      PI2(1;130)=TWOPI
00041      ZERO(1;130)=0.
00042      EPS(1;130)=1.E-50
00043      DBEPS=ALOG10(EPS(1))
00044      ONE(1;130)=1.
C      INITIALIZE CUMULATIVE SAMPLE PATH VARIABLES
00045      CERRNL(1;130)=0.
00046      CESQNL(1;130)=0.
00047      CCSNL(1;130)=0.
00048      CERRPL(1;130)=0.
00049      CESQPL(1;130)=0.
00050      CCSPL(1;130)=0.
C      PRINTOUT PRUBLEM PARAMETERS
00051      WRITE (6,6000) NMC,NSAMP,ALP110,DELF,Q22C,Y1EST,Y2EST,
1      P110,QQ,RX,FTC,DEL,Q22,PDEL,RDEL,A11,A22,CONST,CS(1)
00052      6000 FORMAT(1H1,31X,18HPRUBLEM PARAMETERS/
1      1H0,11X,9HPARAMETER,6X,5HVALUE,11X,9HPARAMETER,
2      6X,5HVALUE/1H0,14X,3HNMC,9X,14,14X,5HNSAMP,8X,14/
3      13X,6HALP110,3X,E15.8,8X,4HDELF,4X,E15.8/
4      14X,4HQ22C,4X,E15.8,8X,5HY1EST,3X,E15.8/
5      14X,5HY2EST,3X,E15.8,8X,4HP110,4X,E15.8/
6      15X,2HQQ,5X,E15.8,9X,2HRX,5X,E15.8/
7      15X,3HFTC,4X,E15.8,9X,3HDEL,4X,E15.8/
8      15X,3HQ22,4X,E15.8,8X,5HPDEL,3X,E15.8/
9      14X,4HRDEL,4X,E15.8,9X,3HA11,4X,E15.8/
A      15X,3HA22,4X,E15.8,8X,5HCONST,3X,E15.8/
B      15X,2HCS,5X,E15.8)
C      BEGIN THE MONTE CARLO PROCESS
C      INITIALIZATION OF THE SUBROUTINES
00053      CALL STATE(0,0,X1,Z1,Z2)
00054      CALL NLF(0,0,0.,0.,SHAT,CHAT,T)
C      MONTE CARLO LOOP
00055      DO 200 K=1,NMC
C      INITIALIZATION OF SAMPLE PATH VARIABLES

```

```

00056      CALL STATE(K,O,X1,Z1,Z2)
00057      CALL NLF(K,O,Z1,Z2,SHAT,CHAT,T)
00058      CALL PLL(K,O,Z1,Z2,X1HAT,P11)
      C      SAMPLE PATH LOOP
00059      DO 100 J=1,NSAMP
00060      CALL STATE(K,J,X1,Z1,Z2)
00061      CALL NLF(K,J,Z1,Z2,SHAT,CHAT,T)
00062      CALL PLL(K,J,Z1,Z2,X1HAT,P11)
      C      STORE THE SAMPLE VARIABLES
00063      SX1(J)=X1
00064      SSHAT(J)=SHAT
00065      SCHAT(J)=CHAT
00066      TNLF(J)=T
00067      SX1HATPL(J)=X1HAT
00068      100 SP11PL(J)=P11
      C      VECTOR ACCUMULATE THE SAMPLE PATH AVERAGES
00069      SX1HATNL(1;130)=VATAN2(SSHAT(1;130),SCHAT(1;130);
      1      SX1HATNL(1;130))
00070      SERRNL(1;130)=SX1(1;130)-SX1HATNL(1;130)
00071      CALL MOD2PI(SERRNL)
00072      SPLJSSNL(1;130)=SSHAT(1;130)*SSHAT(1;130)+SCHAT(1;130)*
      1      SCHAT(1;130)
00073      SPLOSSNL(1;130)=2.0*(1.0-VSQRT(SPLJSSNL(1;130);SPLOSSNL(1;130)))
00074      CERRNL(1;130)=VAVG(CERRNL(1;130),SERRNL(1;130),K;CERRNL(1;130))
00075      TEMP(1;130)=SERRNL(1;130)*SERRNL(1;130)
00076      CESQNL(1;130)=VAVG(CESQNL(1;130),TEMP(1;130),K;CESQNL(1;130))
00077      IF (K.LE.1) GO TO 110
00078      CEVARNL(1;130)=CESQNL(1;130)-CERRNL(1;130)*CERRNL(1;130)
00079      BT(1;130)=(CEVARNL(1;130).LE.EPS(1;130))
00080      CEVARNL(1;130)=QBVMASK(EPS(1;130),CEVARNL(1;130),BT(1;130);
      1      CEVARNL(1;130))
00081      CDBNL(1;130)=VALGG10(CEVARNL(1;130);CDBNL(1;130))
00082      CDBNL(1;130)=10.0*CDBNL(1;130)
00083      110 BT(1;130)=(SERRNL(1;130).GT.CS(1;130))
00084      TEMP(1;130)=QBVMASK(ONE(1;130),ZERO(1;130),BT(1;130);
      1      TEMP(1;130))
00085      CCSNL(1;130)=VAVG(CCSNL(1;130),TEMP(1;130),K;CCSNL(1;130))
00086      SERRPL(1;130)=SX1(1;130)-SX1HATPL(1;130)
00087      CALL MOD2PI(SERRPL)
00088      CERRPL(1;130)=VAVG(CERRPL(1;130),SERRPL(1;130),K;CERRPL(1;130))
00089      TEMP(1;130)=SERRPL(1;130)*SERRPL(1;130)
00090      CESQPL(1;130)=VAVG(CESQPL(1;130),TEMP(1;130),K;CESQPL(1;130))
00091      IF (K.LE.1) GO TO 120
00092      CEVARPL(1;130)=CESQPL(1;130)-CERRPL(1;130)*CERRPL(1;130)
00093      BT(1;130)=(CEVARPL(1;130).LE.EPS(1;130))

```

```

FORTRAN R1.2 CYCLE 115P2      D=8          SOURCE LISTING      13.39 HRS. 31MAY7
00094      CEVARPL(1;130)=Q8VMASK(EPS(1;130),CEVARPL(1;130),BT(1;130);
          1  CEVARPL(1;130))
00095      CDBPL(1;130)=VALDGL0(CEVARPL(1;130);CDBPL(1;130))
00096      CDBPL(1;130)=10.0*CDBPL(1;130)
00097      120 BT(1;130)=(SERRPL(1;130).GT.CS(1;130))
00098      TEMP(1;130)=Q8VMASK(ONE(1;130),ZERQ(1;130),BT(1;130);
          1  TEMP(1;130))
00099      CCSPL(1;130)=VAVG(CCSPL(1;130),TEMP(1;130),K;CCSPL(1;130))
00100      IF (PATH.AND.(K.EQ.1 )) GO TO 130
00101      GO TO 200
C
00102      130 PRINT SAMPLE PATH VARIABLES
00103      6010 WRITE (6,6010)
00104      6010 FORMAT(1H1,36X,21HSAMPLE PATH VARIABLES/
          1  38X,19H(FIRST SAMPLE PATH)/)
00105      WRITE (6,6011)
00106      6011 FORMAT(/18X,9HSX1-      ,6X,
          1  36H      PHASE VARIABLES      /
          2  20X,1H1,13X,11HSX1(I)      ,8X,13HSX1(I+1)      /)
00107      WRITE(6,6100)((I, SX1(I), SX1(I+1)), I=1,129,2)
00108      WRITE (6,6012)
00109      6012 FORMAT(/18X,9HSSHAT-      ,6X,
          1  36H      SIN(SX1) ESTIMATES      /
          2  20X,1H1,13X,11HSSHAT(I)      ,8X,13HSSHAT(I+1)      /)
00110      WRITE(6,6100)((I, SSHAT(I), SSHAT(I+1)), I=1,129,2)
00111      WRITE (6,6013)
00112      6013 FORMAT(/18X,9HSCHAT-      ,6X,
          1  36H      COS(SX1) ESTIMATES      /
          2  20X,1H1,13X,11HSCHAT(I)      ,8X,13HSCHAT(I+1)      /)
00113      WRITE(6,6100)((I, SCHAT(I), SCHAT(I+1)), I=1,129,2)
00114      WRITE (6,6014)
00115      6014 FORMAT(/18X,9HSX1HATNL-      ,6X,
          1  36H      NONLINEAR ESTIMATES      /
          2  20X,1H1,13X,11HSX1HATNL(I)      ,8X,13HSX1HATNL(I+1)      /)
00116      WRITE(6,6100)((I, SX1HATNL(I), SX1HATNL(I+1)), I=1,129,2)
00117      WRITE (6,6015)
00118      6015 FORMAT(/18X,9HSERRNL-      ,6X,
          1  36H      NONLINEAR ERRORS      /
          2  20X,1H1,13X,11HSERRNL(I)      ,8X,13HSERRNL(I+1)      /)
00119      WRITE(6,6100)((I, SERRNL(I), SERRNL(I+1)), I=1,129,2)
00120      WRITE (6,6016)
00121      6016 FORMAT(/18X,9HSPLOSSNL-      ,6X,
          1  36H      NONLINEAR PLOSS FUNCTION      /
          2  20X,1H1,13X,11HSPLJSSNL(I)      ,8X,13HSPLOSSNL(I+1)      /)
00122      WRITE(6,6100)((I, SPLOSSNL(I), SPLOSSNL(I+1)), I=1,129,2)
          WRITE (6,6017)

```



```

FORTRAN R1.2 CYCLE 115P2    D=8                SOURCE LISTING      13.39 HRS. 31MAY7
00123      6017 FORMAT(/18X,9HTNLF-          ,6X,
           1 36H      NONLINEAR EXECUTION TIMES      /
           2 20X,1HI,13X,11HTNLF(I)      ,8X,13HTNLF(I+1)      /)
00124      WRITE(6,6100)((I,TNLF(I),TNLF(I+1)),I=1,129,2)
00125      WRITE (6,6018)
00126      6018 FORMAT(/18X,9HSX1HATPL-      ,6X,
           1 36H      PHASE LOCK LOOP ESTIMATES      /
           2 20X,1HI,13X,11HSX1HATPL(I)      ,8X,13HSX1HATPL(I+1)      /)
00127      WRITE(6,6100)((I, SX1HATPL(I), SX1HATPL(I+1)),I=1,129,2)
00128      WRITE (6,6019)
00129      6019 FORMAT(/18X,9HSERRPL-          ,6X,
           1 36H      PHASE LOCK LOOP ERRORS      /
           2 20X,1HI,13X,11HSERRPL(I)      ,8X,13HSERRPL(I+1)      /)
00130      WRITE(6,6100)((I, SERRPL(I), SERRPL(I+1)),I=1,129,2)
00131      WRITE (6,6020)
00132      6020 FORMAT(/18X,9HSP11PL-          ,6X,
           1 36H      FROM PHASE LOCK RICATTI EQUATION      /
           2 20X,1HI,13X,11HSP11PL(I)      ,8X,13HSP11PL(I+1)      /)
00133      WRITE(6,6100)((I, SP11PL(I), SP11PL(I+1)),I=1,129,2)
00134      200 CONTINUE
C      PRINT CUMULATIVE SAMPLE PATH VARIABLES
00135      IF (CUMPATH.AND.(NMC.GT.1)) GO TO 310
00136      GO TO 400
00137      310 WRITE (6,6030)
00138      6030 FORMAT(1H1,30X,32HCUMULATIVE SAMPLE PATH VARIABLES /)
00139      WRITE (6,6031)
00140      6031 FORMAT(/18X,9HCERRNL-          ,6X,
           1 36H      CUMULATIVE NONLINEAR ERRORS      /
           2 20X,1HI,13X,11HCERRNL(I)      ,8X,13HCERRNL(I+1)      /)
00141      WRITE (6,6100)((I, CERRNL(I), CERRNL(I+1)),I=1,129,2)
00142      WRITE (6,6032)
00143      6032 FORMAT(/18X,9HCERRPL-          ,6X,
           1 36HCUMULATIVE PHASE LOCK ERRORS      /
           2 20X,1HI,13X,11HCERRPL(I)      ,8X,13HCERRPL(I+1)      /)
00144      WRITE (6,6100)((I, CERRPL(I), CERRPL(I+1)),I=1,129,2)
00145      WRITE (6,6033)
00146      6033 FORMAT(/18X,9HCESQNL-          ,6X,
           1 36HCUMULATIVE NONLINEAR SQUARED ERRORS      /
           2 20X,1HI,13X,11HCESQNL(I)      ,8X,13HCESQNL(I+1)      /)
00147      WRITE (6,6100)((I, CESQNL(I), CESQNL(I+1)),I=1,129,2)
00148      WRITE (6,6034)
00149      6034 FORMAT(/18X,9HCESQPL-          ,6X,
           1 36HCUMULATIVE PHASE LOCK SQUARED ERRORS      /
           2 20X,1HI,13X,11HCESQPL(I)      ,8X,13HCESQPL(I+1)      /)
00150      WRITE (6,6100)((I, CESQPL(I), CESQPL(I+1)),I=1,129,2)

```

```

FORTRAN R1.2 CYCLE 115P2    0=8                SOURCE LISTING                13.39 HRS. 31MAY
00151      WRITE (6,6035)
00152      6035 FORMAT(/18X,9HCEVARNL-      ,6X,
1          36HCUMULATIVE NONLINEAR ERROR VARIANCE      /
2          20X,1HI,13X,11HCEVARNL(I) ,8X,13HCEVARNL(I+1) /)
00153      WRITE (6,6100)((I,CEVARNL(I),CEVARNL(I+1)),I=1,129,2)
00154      WRITE (6,6036)
00155      6036 FORMAT(/18X,9HCEVARPL-      ,6X,
1          36HCUMULATIVE PHASE LOCK ERROR VARIANCE      /
2          20X,1HI,13X,11HCEVARPL(I) ,8X,13HCEVARPL(I+1) /)
00156      WRITE (6,6100)((I,CEVARPL(I),CEVARPL(I+1)),I=1,129,2)
00157      WRITE (6,6037)
00158      6037 FORMAT(/18X,9HCDBNL-      ,6X,
1          36HCUMULATIVE NONLINEAR ERROR DECIBELS      /
2          20X,1HI,13X,11HCDBNL(I) ,8X,13HCDBNL(I+1) /)
00159      WRITE (6,6100)((I,CDBNL(I),CDBNL(I+1)),I=1,129,2)
00160      WRITE (6,6038)
00161      6038 FORMAT(/18X,9HCDBPL-      ,6X,
1          36HCUMULATIVE PHASE LOCK ERROR DECIBELS      /
2          20X,1HI,13X,11HCDBPL(I) ,8X,13HCDBPL(I+1) /)
00162      WRITE (6,6100)((I,CDBPL(I),CDBPL(I+1)),I=1,129,2)
00163      WRITE (6,6039)
00164      6039 FORMAT(/18X,9HCCSNL-      ,6X,
1          36HCUMULATIVE NONLINEAR CYCLE SLIPS      /
2          20X,1HI,13X,11HCCSNL(I) ,8X,13HCCSNL(I+1) / /)
00165      WRITE (6,6100)((I,CCSNL(I),CCSNL(I+1)),I=1,129,2)
00166      WRITE (6,6040)
00167      6040 FORMAT(/18X,9HCCSPL-      ,6X,
1          36HCUMULATIVE PHASE LOCK CYCLE SLIPS      /
2          20X,1HI,13X,11HCCSPL(I) ,8X,13HCCSPL(I+1) /)
00168      WRITE (6,6100)((I,CCSPL(I),CCSPL(I+1)),I=1,129,2)
C      COMPUTE THE MUNTE CARLO AVERGES
00169      400 IF (NSAMP.LE.30) GO TO 10
00170      I=NSAMP-30
00171      T=I
00172      XERRNL=Q8SSUM(CERRNL(31;I))/T
00173      XESQNL=Q8SSUM(CESQNL(31;I))/T
00174      XCSNL=Q8SSUM(CCSNL(31;I))/T
00175      XERRPL=Q8SSUM(CERRPL(31;I))/T
00176      XESQPL=Q8SSUM(CESQPL(31;I))/T
00177      XCSPL=Q8SSUM(CCSPL(31;I))/T
00178      XEVARNL=XESQNL-XERRNL*XERRNL
00179      XDBNL=DBEPS
00180      IF (XEVARNL.GT.EPS(1)) XDBNL=10.0*ALOG10(XEVARNL)
00181      XEVARPL=XESQPL-XERRPL*XERRPL
00182      XDBPL=DBEPS

```

```

FORTRAN R1.2 CYCLE 115P2    Q=8    SOURCE LISTING    13.39 HRS. 31MAY7
00183    IF (XEVARPL.GT.EPS(1)) XDBPL=10.*ALOG10(XEVARPL)
          C    PRINT THE MONTE CARLO AVERAGES
00184    WRITE (6,6050) NMC,XERRNL,XERRPL,XESQNL,XESQPL,XEVARNL,
          1    XEVARPL,XDBNL,XDBPL,XCSNL,XCSPL
00185    6050 FORMAT(1H1,25X,30HMONTE CARLO SUMMARY STATISTICS//
          1    32X,1H(,14,14H SAMPLE PATHS)//
          2    36X,16HNONLINEAR FILTER,5X,15HPHASE LOCK LOOP//
          3    14X,14H***VARIABLE***,7X,12H***VALUES***,9X,
          4    12H***VALUES***//14X,13HAVERAGE ERROR,9X,
          5    E15.8,6X,E15.8/
          6    10X,21HAVERAGE SQUARED ERROR,5X,E15.8,6X,E15.8/
          7    14X,14HERPOR VARIANCE,8X,E15.8,6X,E15.8 /
          8    14X,14HVARIANCE IN DB,8X,E15.8,6X,E15.3/
          9    11X,19HAVERAGE CYCLE SLIPS,6X,E15.8,6X,E15.8)
00186    6100 FORMAT(20X,14,8X,E15.8,4X,E15.8)
00187    GO TO 10
00188    500 STOP
00189    END
          NO ERRORS

```



```

FORTAN R1.2 CYCLE 115P2      O=B
00001      SUBROUTINE VPRUP(A,I)
00002      REAL A(16640)
00003      INTEGER I
00004      INTEGER MD1,MD2,MD3,MD4,MD5,MD6,MD7,
1          MD8,MD9,MD10,MD11,MD12,MD13,MD14,MD15,MD16
00005      COMMON /CPROP/ MD1,MD2,MD3,MD4,MD5,MD6,MD7,
1          MD8,MD9,MD10,MD11,MD12,MD13,MD14,MD15,MD16
00006      IF (I.GT.0) GO TO 10
00007      A(MD2;MD1)=A(1;MD1)
00008      A(MD4;MD3)=A(1;MD3)
00009      10 A(MD6;MD5)=A(1;MD5)
00010      A(MD8;MD7)=A(1;MD7)
00011      A(MD10;MD9)=A(1;MD9)
00012      A(MD12;MD11)=A(1;MD11)
00013      A(MD14;MD13)=A(1;MD13)
00014      A(MD16;MD15)=A(1;MD15)
00015      RETURN
00016      END

```

SGURCE LISTING

13.39 HRS. 31MAY7

NO ERRORS

FORTAN R1.2 CYCLE 115P2 D=B

SOURCE LISTING

13.39 HRS. 31MAY7

```
00001 SUBROUTINE MOD2PI(A)
00002 REAL A(130),X(130),Y(130)
00003 BIT BT(130)
00004 COMMON /PROB/ TWOPI,PI
00005 X(1;130)=PI
00006 10 BT(1;130)=(A(1;130).GT.X(1;130))
00007 IF (Q8SCNT(BT(1;130)).EQ.0) GO TO 20
00008 Y(1;130)=A(1;130)-TWOPI
00009 A(1;130)=Q8VMASK(Y(1;130),A(1;130),BT(1;130);A(1;130))
00010 GO TO 10
00011 20 X(1;130)=-PI
00012 30 BT(1;130)=(A(1;130).LT.X(1;130))
00013 IF (Q8SCNT(BT(1;130)).EQ.0) RETURN
00014 Y(1;130)=A(1;130)+TWOPI
00015 A(1;130)=Q8VMASK(Y(1;130),A(1;130),BT(1;130);A(1;130))
00016 GO TO 30
00017 END
```

NO ERRORS



FORTRAN R1.2 CYCLE 115P2 U=8  
00001 REAL FUNCTION VAVG(AV,X,I;\*)  
00002 DESCRIPTOR AV,X,VAVG  
00003 INTEGER I  
00004 REAL XI  
00005 XI=I  
00006 VAVG =((XI-1.)\*AV+X)/XI  
00007 RETURN  
00008 END

SOURCE LISTING

13.39 HRS. 31MAY7

NO ERRORS

FORTTRAN R1.2 CYCLE 115P2 D=B

SOURCE LISTING

13.39 HRS. 31MAY7

```
00001 REAL FUNCTION RNF(INIT)
00002 INTEGER INIT,K,KD,M1,M2,N1,N2,NT,MP
00003 REAL T1,T2
00004 COMMON /RNUM/ K,KD,M1,M2,N1,N2,NT,MP,T1,T2
00005 IF (INIT.EQ.0) GO TO 10
00006 N1=244734
00007 N2=159551
00008 N1=102943
00009 N2=185617
00010 M1=244734
00011 M2=159551
00012 T1=2.**(-18)
00013 T2=2.**(-36)
00014 MP=2**18
00015 10 K=M2*N2
00016 KD=K/MP
00017 NT=K-KD*MP
00018 K=M1*N2+M2*N1+KD
00019 KD=K/MP
00020 N1=K-KD*MP
00021 N2=NT
00022 RNF=N1*T1+N2*T2
00023 RETURN
00024 END
```

NO ERRORS

```

FORTRAN R1.2 CYCLE 115P2    D=B          SOURCE LISTING          13.39 HRS. 31MAY7
00001      REAL FUNCTION GAUSS(INIT,SD,XM)
00002      INTEGER INIT,I,J
00003      REAL SD,XM,TWOPI,X,XR1,XR2
00004      COMMON /GNUM/ I,J,XR2
00005      COMMON /PROB/ TWOPI
00006      IF (INIT.EQ.0) GO TO 10
00007      I=1
00008      J=1
00009      10 IF (J.NE.1) GO TO 20
00010      J=2
00011      XR1=RNF(I)
00012      I=0
00013      XR2=RNF(0)
00014      X=SQRT(ABS(-2.*ALOG(XR1)))
00015      XR2=TWOPI*XR2
00016      XR1=X*SIN(XR2)
00017      XR2=X*COS(XR2)
00018      GAUSS=XR1*SD+XM
00019      RETURN
00020      20 J=1
00021      GAUSS=XR2*SD+XM
00022      RETURN
00023      END
NO ERRORS

```



FORTRAN R1.2 CYCLE 115P2 D=B

SOURCE LISTING

13.39 HRS. 31MAY

```

00001  SUBROUTINE STATE(MC,SAMP,X1,Z1,Z2)
00002  INTEGER MC,SAMP,INIT
00003  REAL X1,Z1,Z2,DEV1,DEV2,DEV3,DEV4,X2
00004  COMMON /STA/ DEV1,DEV2,DEV3,DEV4,INIT
00005  COMMON /PROB/ TWOPI,PI,ALP110,DELF,Q22C,Y1EST,Y2EST,A11,A22,
1     CONST,DEL,FTC,PIDEL,P110,RDEL,RX,QC,Q22,MD,ND
00006  IF (MC.NE.0) GO TO 10
00007  DEV1=SQRT(A11)
00008  DEV2=SQRT(A22)
00009  DEV3=SQRT(RDEL)
00010  DEV4=SQRT(Q22)
00011  INIT=1
00012  RETURN
00013  10 IF (SAMP.GT.0) GO TO 20
00014  X1=GAUSS(INIT,DEV1,Y1EST)
00015  INIT=0
00016  X2=GAUSS(0,DEV2,Y2EST)
00017  RETURN
00018  20 IF (SAMP.LE.1) GO TO 30
00019  X1=X1+X2*DEL
00020  X2=GAUSS(0,DEV4,X2)
00021  30 Z1=GAUSS(0,DEV3,COS(X1))
00022  Z2=GAUSS(0,DEV3,SIN(X1))
00023  RETURN
00024  END

```

NO ERRORS

```

FORTAN R1.2 CYCLE 115P2      U=B          SOURCE LISTING          13.39 HRS. 31MAY71
00001      SUBROUTINE PLL(MC,SAMP,Z1,Z2,X1HAT,PF11)
00002      INTEGER MC,SAMP
00003      REAL Z1,Z2,X1HAT,PF11,DEN,SINF1,COSF1,
1      X2HAT,PD11,PD12,PD22,PN11,PN12,PN22
00004      COMMON /PLO/ DEN,X2HAT,PN11,PN12,PN22
00005      COMMON /PROB/ TWOPI,PI,ALP110,DELF,Q22C,Y1EST,Y2EST,A11,A22,
1      CONST,DEL,FTC,PIDEL,P110,RDEL,RX,QQ,Q22
00006      IF (MC.LE.0) RETURN
00007      IF (SAMP.LE.0) GO TO 20
00008      IF (SAMP.LE.1) GO TO 10
00009      X1HAT=X1HAT+DEL*X2HAT
00010      PD11=(RDEL*(PN11+2.0*PN12*DEL)-PN12*PN12
1      *DEL*DEL)*DEN+PN22*DEL*DEL
00011      PD12=PN12*(RDEL-PN12*DEL)*DEN+PN22*DEL
00012      PD22=-PN12*PN12*DEN+PN22+Q22
00013      PN11=PD11
00014      PN12=PD12
00015      PN22=PD22
00016      DEN=1.0/(PN11+RDEL)
00017      10 PF11=PN11*RDEL*DEN
00018      SINF1=SIN(X1HAT)
00019      COSF1=COS(X1HAT)
00020      X1HAT=X1HAT+DEN*(-PN11*SINF1*Z1+PN11*COSF1*Z2)
00021      X2HAT=X2HAT+DEN*(-PN12*SINF1*Z1+PN12*COSF1*Z2)
00022      RETURN
00023      20 X1HAT=Y1EST
00024      X2HAT=Y2EST
00025      PN11=A11
00026      PN22=A22
00027      PN12=0.
00028      DEN=1.0/(PN11+RDEL)
00029      RETURN
00030      END

```

NO ERRORS

FORTRAN R1.2 CYCLE 115P2 D=B SOURCE LISTING  
 00001 SUBROUTINE NLF(MC,SAMP,Z1,Z2,SHAT,CHAT,TNLF)

13.39 HRS. 31MAY7

C  
 C  
 C  
 C  
 C  
 C  
 C  
 C  
 C  
 C

POINTMASS FILTER FOR TWO DIMENSIONAL PHASE ESTIMATION  
 PROGRAMMED BY KENNETH D. SENNE JUNE 24, 1976

00002 INTEGER MC,SAMP,MD,ND,MND,MND1  
 00003 INTEGER MD1,MD2,MD3,MD4,MD5,MD6,MD7,  
 1 MD8,MD9,MD10,MD11,MD12,MD13,MD14,MD15,MD16  
 00004 REAL Z1,Z2,SHAT,CHAT,TNLF  
 00005 INTEGER I,I1,J,J1,J2,K,NC,NT,NTERM,NTERM33  
 00006 REAL A11,A22,CL,CNORM,CONST,CR,PI,PIDEL,J22,T,  
 1 TT,Y1EST,Y2EST,TEMP,TEMP1,TEMP2  
 00007 REAL S1(64),S2(64),SIGMA(64),PSI(256),A(256)  
 00008 REAL IN(8)  
 00009 BIT DBT, BT(16640)  
 00010 INTEGER DJNM,DJNS  
 00011 INTEGER JNS(256),JNM(512)  
 00012 REAL COSY(16384),DELJ(16640),JO(16384),JN(16384),JN1(32768),  
 1 JNA(32768),SINY(16384),SN1(16384)  
 00013 DESCRIPTOR DS1,DS2,DSN1,DSN2,DJN,DJNS,DJNA1,DJNA2,DDELJ,DJN1,  
 1 DJNAENT,DJNABNT,DJNANC,DJNAJ1,DJNAJ2,DSINY,DCOSY,DSN1A  
 00014 DESCRIPTOR DJNM,DJN1D,DJNA1S,DJN1S,DJNA2S,DBT,DJNA,DJND,DJN1F  
 00015 COMMON /PROB/ TWOPI,PI,ALP110,DELF,Q22C,Y1EST,Y2EST,A11,A22,  
 1 CONST,DEL,FTC,PIDEL,P110,RDEL,RX,QQ,Q22,MD,ND  
 00016 COMMON /NLFC/ NC,NT,NTERM,NTERM33,S1,S2,SIGMA,PSI,A,COSY,DELJ,  
 1 JO,JN,JNS,SINY  
 00017 COMMON /CPROP/ MDD,MD2,MD3,MD4,MD5,MD6,MD7,  
 1 MD8,MD9,MD10,MD11,MD12,MD13,MD14,MD15,MD16  
 00018 IF (SAMP.LE.0) GO TO 100

C  
 C  
 C  
 C  
 C  
 C  
 C  
 C  
 C

SAMPLE PATH UPDATE TAKES PLACE HERE

SET CLOCK

00019 CALL J3CLOCK(S(T,TT))



FORTRAN R1.2 CYCLE 115P2 D=8  
C  
C  
EVALUATE SENSOR TERMS

SOURCE LISTING

13.39 HRS. 31MAY7

00020 DSN1=Z1\*DS1  
00021 DSN2=Z2\*DS2  
00022 DSN1=DSN1+DSN2  
00023 DSN1=VEXP(DSN1;DSN1)

C  
C  
C  
PROPAGATE SENSOR TERMS

00024 SN1(33;32)=SN1(1;32)  
00025 SN1(65;64)=SN1(1;64)  
00026 SN1(129;128)=SN1(1;128)  
00027 SN1(257;256)=SN1(1;256)  
00028 SN1(1025;1024)=SN1(1;1024)  
00029 SN1(2049;2048)=SN1(1;2048)

C  
C  
C  
SCRAMBLE THE JN TO ORDER FOR J(N+1)

00030 CALL QBVXTQV(X'02',0,DJNM,0,DJND,0,DJN1F)  
00031 CALL QBVXTQV(X'02',0,DJNS,0,DJN1D,0,DJNA1S)

C  
C  
C  
FORM THE INTERPOLATED MATRIX

00032 DJN1S=DJNA2S-DJNA1S  
00033 DJN1S=DDELJ\*DJN1S  
00034 DJN1S=DJNA1S+DJN1S

C  
C  
C  
COMPRESS OUT THE LAST ROW OF INTERPOLATED VECTOR

00035 DJNA=QBVCMPRS(DJN1S,DYT;DJNA)

C  
C  
C  
COPY THE END COLUMNS

00036 DJNAENT=DJNABNT

C  
C  
C  
INITIALIZE CONVOLUTION (A(0)=1)

00037 DJN1=DJNANC

C  
C  
C  
CONVOLUTION LOOP

00038 J1=NC  
00039 J2=NC  
00040 DO 10 I=1,NTerm  
00041 J1=J1+MD

FORTTRAN R1.2 CYCLE 115P2 O=B

SOURCE LISTING

13.39 HRS. 31MAY7

```

00042      J2=J2-MD
00043      ASSIGN DJNAJ1,JNA(J1;MND)
00044      ASSIGN DJNAJ2,JNA(J2;MND)
00045      DJN=DJNAJ1+DJNAJ2
00046      DJN=A(I)*DJN
00047      10 DJN1=DJN1+DJN
           C
           C      MULTIPLY BY SENSOR TERMS
           C
00048      DJN1=DSN1A*DJN1
           C
           C      GET NORMALIZATION CONSTANT
           C
00049      CNORM=SUMLOG(JN1)
00050      CNORM=1.0/CNCRM
           C
           C      TRANSFER THE NORMALIZED DENSITY
           C
00051      DJN=CNORM*DJN1
           C
           C      CUMULATE ESTIMATES
           C
00052      DJNA1=DSINY*DJN
00053      SHAT=SUMLOG(JNA)
00054      DJNA1=DCOSY*DJN
00055      CHAT=SUMLOG(JNA)
           C
           C      TIMEOUT
           C
00056      CALL Q3CLOCKS(TNLF,TT)
00057      RETURN
           C
           C-----
           C
           C-----
           C
           C      SAMPLE PATH INITIALIZATION TAKES PLACE HERE
           C
00058      100 IF (MC.LE.0) GO TO 200
           C
           C      TRANSFER THE INITIAL DENSITY FOR NEW SAMPLE PATH
           C
00059      JN(1;MND)=JO(1;MND)
00060      RETURN

```



C  
C  
C  
C  
C  
C  
C  
C  
C  
C

GLOBAL INITIALIZATIONS OCCUR HERE FOR THE ENTIRE RUN

DETERMINE THE NUMBER OF CONVOLUTION POINTS

```
00061 200 NTERM=(ND/2.)*SQRT(50.*Q22)/PIDEL+0.5
00062 MD1=MD+1
00063 MDD=MD
00064 MD2=MDD+1
00065 MD3=MDD*2
00066 MD4=MD3+1
00067 MD5=MD3*2
00068 MD6=MD5+1
00069 MD7=MD5*2
00070 MD8=MD7+1
00071 MD9=MD7*2
00072 MD10=MD9+1
00073 MD11=MD9*2
00074 MD12=MD11+1
00075 MD13=MD11*2
00076 MD14=MD13+1
00077 MD15=MD13*2
00078 MD16=MD15+1
00079 MND=MD*ND
00080 M1ND=MD1*ND
00081 MND1=MND+1
00082 NTERM33=MD*NTERM
00083 NT=2*NTERM33
00084 NC=NTERM33+1
00085 MND2=2*MND
00086 ND2=ND*2
```

C  
C  
C

SET UP THE VECTOR DESCRIPTORS FOR THE UPDATE FUNCTIONS

```
00087 ASSIGN DS1,S1(1;MD)
00088 ASSIGN DS2,S2(1;MD)
00089 ASSIGN DSN1,SN1(1;MD)
00090 ASSIGN DSN2,JNA(1;MD)
00091 ASSIGN DJN,JN(1;MND)
```

FORTRAN R1.2 CYCLE 115P2 U=8

SOURCE LISTING

13.39 HRS. 31MAY7

```

00092      ASSIGN DJNM,JNM(1;ND2)
00093      ASSIGN DJND,JN(1;MD)
00094      ASSIGN DJN1F,JN1(1;MND2)
00095      ASSIGN DJNS,JNS(1;ND)
00096      ASSIGN DJN1D,JN1(1;MD1)
00097      ASSIGN DJNA1S,JNA(1;M1ND)
00098      ASSIGN DJN1S,JN1(1;M1ND)
00099      ASSIGN DJNA2S,JNA(2;M1ND)
00100      ASSIGN DDELJ,DELJ(1;MND)
00101      ASSIGN DBT,BT(1;M1ND)
00102      ASSIGN DJNA,JNA(1;MND)
00103      ASSIGN DJN1,JN1(1;MND)
00104      ASSIGN DJNAENT,JNA(MND1;NT)
00105      ASSIGN DJNABNT,JNA(1;NT)
00106      ASSIGN DJNANC,JNA(NC;MND)
00107      ASSIGN DSN1A,SN1(1;MND)
00108      ASSIGN DSINY,SINY(1;MND)
00109      ASSIGN DCOSY,COSY(1;MND)
00110      ASSIGN DJNA1,JNA(1;MND)

```

C  
C  
C

PHASE VARIABLES

```

00111      DO 210 I=1,MD
00112      SIGMA(I)=PI*((2.*I-1.)/MD -1.)
00113      COSY(I)=COS(SIGMA(I))
00114      SINY(I)=SIN(SIGMA(I))
00115      S1(I)=COSY(I)/RDEL
00116      210 S2(I)=SINY(I)/RDEL
00117      CALL VPROP(SINY,0)
00118      CALL VPROP(COSY,0)

```

C  
C  
C

PHASE RATE VARIABLES

```

00119      DO 220 I=1,ND
00120      220 PSI(I)=PIDEL*((2.*I-1.)/ND -1.)

```

C  
C  
C

SET UP THE BIT VECTOR

```

00121      I1=1
00122      DO 235 I=1,ND
00123      DO 230 J=1,MD
00124      BT(I1)=B'1'
00125      230 I1=I1+1
00126      BT(I1)=B'0'
00127      235 I1=I1+1

```

C  
C  
C

SETUP THE TRANSFER MATRIX

00128 DO 240 J=1,ND  
00129 J1=MOD(ND-1-NTERM+J,ND)\*MD\*2  
00130 I1=J1+MOD(MD+MD/2+33-(135-NTERM+J)/4,MD)  
00131 240 JNS(J)=I1

C  
C  
C

SETUP INTERPOLATION MATRIX

00132 IN(1)=0.875  
00133 IN(2)=0.625  
00134 IN(3)=0.375  
00135 IN(4)=0.125  
00136 IN(5)=IN(1)  
00137 IN(6)=IN(2)  
00138 IN(7)=IN(3)  
00139 IN(8)=IN(4)  
00140 J=MOD(NTERM,4)  
00141 DO 245 I=1,4  
00142 I1=(I-1)\*MD1+1  
00143 J1=I+4-J  
00144 T=IN(J1)  
00145 245 DELJ(I1;MD1)=T

C  
C  
C

SET UP THE EXPANSION VECTOR

00146 I1=1  
00147 J1=4\*MD1  
00148 DO 250 I=1,MD  
00149 DO 250 J=1,J1  
00150 J2=I1+J1  
00151 DELJ(J2)=DELJ(I1)  
00152 250 I1=I1+1  
00153 I1=0  
00154 I2=2\*ND  
00155 DO 265 I=2,I2,2  
00156 JNM(I-1)=I1  
00157 JNM(I)=I1  
00158 265 I1=I1+MD

C  
C  
C

EVALUATE CONVOLUTION TERMS A(I)

00159 DO 280 I=1,NTERM  
00160 T=I



FORTRAN R1.2 CYCLE 115P2 O=B

SOURCE LISTING

13.39 HRS. 31MAY7

```

00161      TT=ND
00162      TEMP=T/TT
00163      TEMP=CONST*TEMP*TEMP
00164      A(I)=0.
00165      IF (TEMP.GT.-47) A(I)=EXP(TEMP)
00166      280 CONTINUE
      C
      C      CONSTRUCT THE A PRIORI DENSITY
      C
00167      CNORM=1.0/(TWOPI*SQRT(A11*A22))
00168      CL=-0.5/A22
00169      SI=-0.5/A11
00170      DO 290 I=1,MD
00171      I1=I
00172      CR=SIGMA(I)-Y1EST
00173      CR=CR*CR*SI
00174      DO 290 J=1,ND
00175      TEMP=PSI(J)-Y2EST
00176      JO(I1 )=EXP(TEMP*TEMP*CL+CR)*CNORM
00177      290 I1=I1+MD
      C
      C      WRITE OUT PARAMS OF NLF
      C
00178      WRITE (6,6000) MD,ND,MD1,ND
00179      6000 FORMAT(1H0,26X,27HPPOINT MASS NONLINEAR FILTER//1H ,
1      28X,24HVERSION 2, CODED 6/27/76//1H ,
2      18X,I3,1HX,I3,25H DENSITIES REPRESENTED BY ,I3,14X,I3)
00180      WRITE (6,6001) NTERM,(A(I),I=1,NTERM)
00181      6001 FORMAT(1H ,33X,7HA(1)-A(,I2,2H) /(1X,5E15.3))
00182      RETURN
      C
      C-----
      C
00183      END
      NO ERRORS

```

```

FORTRAN R1.2 CYCLE 115P2    U=B          SOURCE LISTING          13.39 HRS. 31MAY7
00001      FUNCTION SUMLOG(A)
00002      REAL A(8192), C(4096)

      C
      C      SUMLOG = SUM(A(1), . . . , A(2**NPA))
      C      DOMAIN = 8 .LE. NPA .LE. 13
00003      NPA = 12
00004      NA = 2**NPA
00005      LC = NA/2
00006      C(1;LC) = A(1;LC)+A(LC+1; LC)
      C      LOOP
00007      20      LC = LC/2
00008      IF(LC .LT. 4) GOTO 50
00009      C(1;LC) = C(1;LC)+C(LC+1; LC)
00010      GOTO 20
      C      END LOOP
00011      50      CONTINUE
00012      SUMLOG = C(1) + C(2) + C(3)+C(4)
00013      RETURN
00014      END
NO ERRORS

```

### 1 - 3 Cray Code

The Cray 1 from our point of view had the most potential for our problem. However the code development centered on tricks to make the Cray's compiler use the full potential of the machine; in particular to force chaining and efficient use of the available hardware potentialities. It would seem that assembly language coding of this machine should be undertaken in order to effectively use the potential of this machine. We achieved 33 megaflops with the following code. The reader should note that the philosophy that is most useful here is to produce a small number of loops which perform a large number of instructions in the inner loop.



```

C      CRAY FORTRAN COMPILER VERSION 1.05X 02/21/79
C      COMPILATION DATE AND TIME          05/21/79   -   07:46:59
      SUBROUTINE NLF(MC,SAMP,Z1,Z2,SHAT,CHAT,TNLF)
      INTEGER MC,SAMP
      REAL Z1,Z2,SHAT,CHAT,TNLF
      COMMON /LCH1/ T20A, T25A, T30A, T40A,T60A,T70A,T90A
      INTEGER I,I1,J,K,NC,NTERM,NSIZE
      INTEGER JNS(128)
      REAL ALP110,A11,A22,CL,CNORM,CONST,CR,DEL,DELF,FTC,PI,PIDEL,P110,
1      QQ,Q22,Q22C,RDEL,RX,SI,T,TEMP,TT,T,OPT,Y1EST,Y2EST
      REAL COSY(32),SINY(32),SN1(32),S1(32),S2(32),SIGMA(32),TROW(32)
      REAL A(10),DELJ(128),PSI(128),V1(128),V2(128)
      REAL JN(33,129),JN1(33,149),JO(33,128)
      COMMON /PROB/ TWOPI,PI,ALP110,DELF,Q22C,Y1EST,Y2EST,
1      A11,A22,CONST,DEL,FTC,PIDEL,P110,RDEL,RX,QQ,Q22
      COMMON /NLFC/ NC,NT,NTERM,S1,S2,SIGMA,PST,A,COSY,
1      DELJ,JO,JN,SINY

C      IF SAMP NOT POSITIVE THEN REINITIALIZE

      IF (SAMP.LE.0) GO TO 100

C      THE FOLLOWING CONSTITUTES THE TIME SEGMENT

C      SET CLOCK

      T=SECOND(I)

C      EVALUATE SENSOR TERMS

      DO 10 I=1,32
      V1(I)=Z1*S1(I)+Z2*S2(I)
C      *** NEXT ONE OUT FOR CRAY ***
C      IF (V1(I).LT.-115.) V1(I)=-115.
10     SN1(I)=EXP(V1(I))

C      TRANSFER JN WITH COLUMNS CYCLICALLY ROTATED TO JN1

      T1 = SECOND(I)
      DO 20 J=1,128
C      CDIR$ IVDEP
      K=129-J
      DO 15 I=1,32
15     JN(I+32,K)=JN(I,K)
      DO 20 I=1,33
      JN1(I,K+10)=JN(I+JNS(K),K)
20     CCONTINUE
      T20= SECOND(I) - T1

C      INTERPOLATE IN JN1 BETWEEN ADJACENT ROWS

      T1 = SECOND(I)
      DO 25 I=1,32
      DO 25 J=11,138
25     JN1(I,J)=JN1(I+1,J)-JN1(I,J))*DELJ(J-10)+JN1(I,J)
      T25= SECOND(I) - T1

```

C EXPAND ENDS OF JN1 BY CYCLICALLY COPYING COLUMNS

```

T2=SECOND(1)
DO 30 J=1, NTERM
DO 30 I=1, 32
JN1(I, -J+11)=JN1(I, -J+139)
30 JN1(I, J+138)=JN1(I, J+10)
T30= SECOND(1) - T1

```

C CONVOLUTION IN JN1 TO JN

```

T1=SECOND(1)
DO 40 I=1, 32
DO 40 J=1, 128
JN(I, J)=JN1(I, J+10) + A(1)*(JN1(I, J+9) + JN1(I, J+11))
1 + A(2)*(JN1(I, J+8) + JN1(I, J+12))
2 + A(3)*(JN1(I, J+7) + JN1(I, J+13))
3 + A(4)*(JN1(I, J+6) + JN1(I, J+14))
4 + A(5)*(JN1(I, J+5) + JN1(I, J+15))
40 CONTINUE
T40= SECOND(1) - T1

```

C ACCUMULATE ROW SUMS BY COLUMN

```

DO 50 I=1, 32
50 TROW(I)=JN(I, 1)
T1=SECOND(1)
DO 60 J=2, 128
DO 60 I=1, 32
60 TROW(I)=TROW(I)+JN(I, J)
T60= SECOND(1) - T1

```

C COMPUTE ESTIMATES AND NORMALIZATION CONSTANT

```

V1(1)=TROW(1)*SN1(1)
CNORM=V1(1)
T1= SECOND(1)
DO 70 I=2, 32
V1(I)=TROW(I)*SN1(I)
70 CNORM=CNORM+V1(I)
T70= SECOND(1) - T1
SHAT=DOT(V1, 1, SINY, 1, 32)
CHAT=DOT(V1, 1, COSY, 1, 32)
CNORM=1./CNORM
SHAT=SHAT*CNORM
CHAT=CHAT*CNORM

```

C TRANSFER NORMALIZED DENSITY

```

T1=SECOND(1)
DO 90 I=1, 32
TEMP=SN1(I)*CNORM
DO 90 J=1, 128
JN(I, J)=TEMP*JN(I, J)
90 CONTINUE
T90= SECOND(1) - T1
TNLF=SECOND(TT)-T
PRINT 1234, T20, T25, T30, T40, T60, T70, T90
1234 FORMAT(" 20, 25, 30, 40, 60, 70, 90 ", 7F12.8)

```

```

T20A=T20A+T20
T25A=T25A+T25
T30A=T30A+T30
T40A=T40A+T40
T60A=T60A+T60
T70A=T70A+T70
T90A=T90A+T90

```

```

C      THE VARIABLES ABOVE ARE INITIALIZED TO ZERO BY THE LOADER SINCE
C      THEY ARE IN LABELLED COMMON (SOPPY BUT SHOULD BE OK).

```

```

C      TIMEOUT

```

```

C      THIS ENDS THE TIMED SEGMENT

```

```

      RETURN

```

```

C * * * * NOTHING BELOW THIS POINT REQUIRES VECTORIZATION * * * *

```

```

C      IF MC NOT POSITIVE THEN GLOBAL INITIALIZE

```

```

100  IF (MC.LE.0) GO TO 200

```

```

C      SAMPLE PATH INITIALIZATION

```

```

      DO 110 I=1,32
      DO 110 J=1,128
110  JN(I,J)=JO(I,J)
      RETURN

```

```

C      GLOBAL INITIALIZATIONS FOR NONLINEAR FILTER

```

```

200  NSIZE=10
      NTERM=64.0*SQRT(50.*Q22)/PIDEL+0.5
      IF(NTERM.GT.NSIZE) NTERM=NSIZE

```

```

C      PHASE VARIABLES

```

```

      DO 210 I=1,32
      SIGMA(I)=PI*((2.*I-1.)/32.-1.)
      COSY(I)=COS(SIGMA(I))
      SINY(I)=SIN(SIGMA(I))
      S1(I)=COSY(I)/RDEL
210  S2(I)=SINY(I)/RDEL

```

```

C      PHASE RATE VARIABLES

```

```

      DO 220 I=1,128
220  PSI(I)=PIDEL*((2.*I-1.)/128.-1.)

```

```

C      SETUP THE TRANSFER MATRIX

```

```

      DO 240 I=1,128
240  JNS(J)=MOD(47-(J-1)/4,32)

```



```

C      SETUP THE INTERPOLATION VECTOR

      DELJ(1)=0.875
      DELJ(2)=0.625
      DELJ(3)=0.375
      DELJ(4)=0.125
      DO 250 I=5,125,4
      DELJ(I)=DELJ(I-4)
      DELJ(I+1)=DELJ(I-3)
      DELJ(I+2)=DELJ(I-2)
250    DELJ(I+3)=DELJ(I-1)

C      EVALUATE CONVOLUTION TERMS A(I)

      DO 280 I=1,NTERM
      TEMP=I/128.
      TIMP=CONST*TEMP*TEMP
      A(I)=0.
      IF (TEMP.GT.-47.) A(I)=EXP(TEMP)
280    CONTINUE

C      CONSTRUCT THE A PRIORI DENSITY

      CNORM=1.0/(TWOPI*SQRT(A11*A22))
      CL=-0.5/A22
      SI=-0.5/A11
      DO 290 I=1,32
      CR=SIGMA(I)-Y1EST
      CR=CR*CR*SI
      DO 290 J=1,128
      TEMP=PSI(J)-Y2EST
      TEMP=TEMP*TEMP*CL*CR
C      *** NEXT TWO OUT FOR CRAY ***
C      JO(I,J)=0.
C      IF (TEMP.GT.-115.) JO(I,J)=EXP(TEMP)*CNORM
C      *** NEXT ONE IN FOR CRAY ***
      JO(I,J)=EXP(TEMP)*CNORM
290    CONTINUE
      RETURN
      END

```

>

## II - 1 CDC 7600 Code for the 3-D Problem

The three dimensional phase demodulation program code was developed simultaneously for the 7600 and the Star 100 in order to have a check on each. The 7600 was not effective on this program as with level 433 the optimizing compiler did not produce runnable code, the extended memory address, calculations failed. When the Opt=1 compiler was used, times of 20 to 30 times slower than the Star resulted, while on the 2D problem the 7600 was only 5 times slower than Star. The compiler failure was submitted to Control Data as a problem and acknowledged but never solved. The reader could view the 7600 code as the scalar version of the 3D Star Code which follows in II - 2. It is apparent that the 7600 is not as effective as the Star and Cray on problems with large memory requirement, i.e. around 350K.

```

1      PROGRAM MAIN(INPLT,OUTPUT,PUNCH,TAPE6=OUTPUT,TAPE5=INPUT)
      DIMENSION XOAT(130,10),Y1(35),Y2(135),EXP33(16,16),YA(35),
      SET(16),EJ(96),EK(16),
      SEXPON(35),EXDON(17),Y3(17)
5      REAL COSY(24576),SINY(24576),SN1(24576),SN2(1536),JN(24576),
      BJN1(26113),JNA(54272),DELJ(26112),S1(16),S2(16),YR(24576),D(2000),
      SYC(16)
      INTEGER JNS(1536),JNF(3072)
C      BIT R3(26112)
10     LOGICAL R3( 26112 )
      LEVEL 2,JNA
      LEVEL 2,DELJ,JN1,YR
      LEVEL 2,COSY,SINY,SN1
      LEVEL 2,SN2,JNS
15     LEVEL 2,R3
      COMMON/GN/JGAUSS,XZZ7(2)
      COMMON /A/JNA
      COMMON /B/ DELJ,JN1,YR
      COMMON /C/ COSY,SINY,SN1,SN2,JNS,R3
20     NAMELIST /INSTR/Y3EST,Q33C,ALF,GAM,Y1EST,Y2EST,ALP110,DELF,
      Q22C,NUM1,NUM2,NO2,NO3
      WRITE(6,666)
666    FORMAT(1H1,5HINPUT)
      READ(5,INSTR)
      WRITE(6,INSTR)
25     JGAUSS = 0
      P110 = 10.**(ALP110/10.)
      Q0 = Q22C**(.25)
      RX = (P110/(SQRT(2.0)*Q0))**(.40/3.0)
30     FTC = SQRT(2.0)*RX**(.25)/Q0
      DELT = DELF*FTC
      Q22 = Q22C*DELT
      R11 = RX/DELT
      P220 = P110*SQRT(Q22C/RX)
35     R11M1=1./P11
      ALFD = ALF*DELT
      BET = 1.0 - ALFD
      A11 = 10.**( (ALP110+GAM)/10.)
      A22 = P220
40     P330 = .5*Q33C/ALF
      A33 = 2.0*P330
      Q33 = Q33C*DELT
      DEV1 = SQRT(A11)
      DEV2 = SQRT(A22)
45     DEV3 = SQRT(P11)
      DEV4 = SQRT(A33)
      DEVQ2 = SQRT(Q22)
      DEVQ3 = SQRT(Q33)
      KOUNT = 1
50     ISAMP = 1
      NSAMP = 0
      SUMP1 = 0.0
      SUMP2 = 0.0
      SUMP3 = 0.0
55     DELSQ = DELT**2
      PI = 4.*ATAN(1.)
      PI2 = 2.0*PI

```



```

        PI0LT = PI/DELT
        PINV = 1.0/PI
50      PI20LT = 2.0*PI0LT
        U1 = NUM1
        U2 = NUM2
        U3 = NUM3
        IY2 = U2/PI20LT*SQRT(50.*022)+.5
65      NTERM = IY2
        NTERM1 = NTERM + 1
        NTRM16 = NTERM*16
        NC = NTRM16 + 1
        NT = 2*NTRM16
70      NT1536 = NT + 1536
        R55 = .5/P11
        CL = -.5/A22
        CM = -.5/A33
        SI = -.5/A11
75      C ***** GPID Y1, Y2 AND YA *****
        EDG1 = PI/U1
        EDG2 = PI0LT/U2
        DO 40 I = 1,NUM1
            X = I - 1
            X = X/U1
80      Y1(I) = -PI + X*PI2 + EDG1
        40 CONTINUE
        DO 50 I = 1,NUM2
            X = I - 1
            X = X/U2
90      Y2(I) = -PI0LT + X*PI20LT + EDG2
        50 CONTINUE
        DO 51 I = 1,IY2
            X = I
            X = X/U2
95      Y3(I) = X
        51 CONTINUE
        DO 55 I = 1,NUM1
            COSY(I) = COS(Y1(I))
            SINY(I) = SIN(Y1(I))
95      CONTINUE
        DO 383 I = 1,16
            S1(I) = COSY(I)/P11
            S2(I) = SINY(I)/P11
100     383 CONTINUE
        CALL VPRCP(SINY,SINY,16,24576,16)
        CALL VPROP(COSY,COSY,16,24576,16)
71      XP=.5*SQRT(A33)
        YY3 = (NUM3 - 1.0)/2.0 + 1.0
105     IY3 = YY3
        DO 60 I = 1,NUM3
            XX = I - YY3
            YA(I) = Y3EST + XP*XX
            YC(I) = Y3EST + XP*XX
110     60 CONTINUE
        C ***** DYNAMIC EXPONENTIALS *****
        IF (IY2 .EQ. 0) GO TO 153
        DO 150 I = 1,IY2
            DON=PI0LT*PI20LT

```

```

115      EXDON(I) = EXP(-DON/022*(Y3(I)**2))
150      CONTINUE
      DO 152 I = 1,IY2
      EXPON(I) = EXDON(IY2+1-I)
      EXPON(IY2+1+I) = EXDON(I)
120      152 CONTINUE
153      EXPON(IY2+1) = .5
      IYY = 2*IY2 + 1
      LTERM2 = 0
      DO 720 K = 1,16
125      DO 720 I = 1,16
      XNUM = (K - I)*XP + ALFO*(YA(I) - 1.)
      XNUM = -.5/033*XNUM**2
      EXP33(I,K) = 0.0
      IF (XNUM .LT. -27.) GO TO 720
130      EXP33(I,K) = EXP(XNUM)
      720 CONTINUE
      LTERM = 0
      LTRM16 = LTERM*16
      LTERM1 = LTERM + 1
135      LC = LTRM16 + 1
      NS = NT1536 *LTERM + NC
C      NOT ON ORIGINAL LISTING, BUT ON ICASE REPORT LISTING
      I = 0
      DO 339 K = 1,16
140      DO 339 N = 1,16
      DO 339 J = NTERM1,IYY
      I = I + 1
      Q(I) = EXPON(J)*EXP33(N,K)
      339 CONTINUE
145      ALOSS=A33
      ALOSS0=ALOSS
      X3EST=Y3EST
      X3EST0=Y3EST
C ***** INITIAL DENSITY *****
150      DO 155 I=1,16
      XXX=SI*(Y1(I)-Y1EST)**2
      IF(XXX .LT. -27) GO TO 154
      EI(I)=EXP(XXX)
      GO TO 155
155      154 EI(I)=0.0
      155 CONTINUE
      DO 157 J=1,96
      YYY=CL*(Y2(J)-Y2EST)**2
      IF(YYY .LT. -27) GO TO 156
160      EJ(J)=EXP(YYY)
      GO TO 157
      156 EJ(J)=0.0
      157 CONTINUE
      DO 159 K=1,16
165      Z77=CM*(YA(K)-Y3EST)**2
      IF(Z77 .LT. -27) GO TO 158
      EK(K)=EXP(Z77)
      GO TO 159
      158 EK(K)=0.0
      159 CONTINUE
170      TJK = 0

```

```

      DO 160 K = 1,16
        DO 160 J = 1,96
          DO 160 I = 1,16
            IJK = IJK + 1
            JN(IJK) = EK(K) * EI(I) * EJ(J)
          160 CONTINUE
        C WRITE(6,9998) JN
        9998 FORMAT(1PAE14.6)
      C ***** INTEGER ARRANGMENT *****
      DO 225 I = 1,26112
        R3(I) = .TRUE.
      225 CONTINUE
      T = 0
    195 DO 300 K = 1,16
      DO 300 J = 1,96
        I = T + 17
        R3(I) = .FALSE.
      300 CONTINUE
    190 DO 320 K = 1,3071,2
      JNF(K) = (K - 1)*9
    320 JNF(K+1) = JNF(K)
      I = 0
      J1 = 0
    195 DO 332 K = 1,16
      DO 332 J = 1,96
        I = T + 1
        I1 = J1 + MOD(23-(J-1)/6,16)
        JNS(I) = I1
        J1 = J1 + 32
      332 CONTINUE
    DO 7332 I = 1,17
      DELJ(I) = 11./12.
      DELJ(I+17) = .75
      DELJ(I+34) = 7./12.
      DELJ(I+51) = 5./12.
      DELJ(I+69) = .25
      DELJ(I+85) = 1./12.
    7332 CONTINUE
    C CALL VPROP1(DELJ(*****))
    CALL VPROP(DELJ,DELJ,102,26310,102)
    11 CONTINUE
    KOUNT = 1
    CALL GAUSS(JSEED,DEV1,Y1EST,X1)
    X0AT(KOUNT,1) = X1
    215 CALL GAUSS(JSEED,DEV2,Y2EST,X2)
    CALL GAUSS(JSEED,DEV4,Y3EST,X3)
    ACOS=EXP(X3-1.)*COS(Y1)
    ASIN=EXP(X3-1.)*SIN(Y1)
    220 CALL GAUSS(JSEED,DEV3,ACOS,71)
    CALL GAUSS(JSEED,DEV3,ASIN,72)
    GO TO 470
    450 CONTINUE
    Y1 = X1 + Y2*DEL1
    X0AT(KOUNT,1) = Y1
    CALL GAUSS(JSEED,DEV02,X2,X2)
    X3 = X3*RET + ALF0
    CALL GAUSS(JSEED,DEV03,X3,X3)

```



```

      XDAT(KOUNT,5)=X3
230      ACOS=EXP(X3-1.)*COS(Y1)
      ASIN=EXP(X3-1.)*SIN(X1)
      CALL GAUSS(JSEED,DEV3,ACOS,71)
      CALL GAUSS(JSEED,DEV3,ASIN,72)
      XP = .5*SQRT(ALOSS)
235      C      XP=.5*AMAX1(.001,SQRT(ALOSS))
      XPO=.5*SQRT(ALOSS0)
      C      LTERM = 0
      DO 600 I = 1,NUM3
          XX = I - YY3
240          YA(I)=XTEST0+XX*XPO
          YC(I)=XTEST+XX*XP
      600      CONTINUE
      DO 730 K = 1,16
245      DO 730 I = 1,16
          XNUM=ALF0*(YA(I)-1.)+YC(K)-YA(I)
          XNUM = -.5/033*XNUM**2
          EXP33(I,K) = 0.0
          IF (XNUM .LT. -27.) GO TO 730
          EXP33(I,K) = EXP(XNUM)
250      730      CONTINUE
          I = 0
          DO 340 K = 1,16
              DO 340 N = 1,16
                  TEMP = EXP33(N,K)
255                  DO 340 J = NTERM1,IYY
                      I = I + 1
                      340      D(I) = EXPON(J)*TEMP
          470      CONTINUE
      C ***** SENSOR FUNCTION *****
260      CALL SECOND(TIMEIN)
      DO 7500 I = 1,16
          R11TZ1=71*R11M1
          R11TZ2=72*R11M1
          S1(I)=R11TZ1*COS(Y1(I))
265      S2(I)=R11TZ2*SIN(Y1(I))
      7500      S1(I) = S1(I) + S2(I)
          J = 0
          DO 500 K = 1,16
              DO 860 KK = 1,16
270              S2(KK)=S1(KK)*EXP(YA(K)-1.)
                  SN2(KK) = EXP(S2(KK))
          860      CONTINUE
      C ***** CALL VPROP(SN2,0) *****
          CALL VPROP(SN2,SN2,16,1530,16)
275      DO 870 KK = 1,1536
          SN1(KK+J) = SN2(KK)
      870      CONTINUE
          DO 880 KK = 1,16
              S2(KK)=-055*EXP(YA(K)-1.)*EXP(YA(K)-1.)
280              SN2(KK) = EXP(S2(KK))
          880      CONTINUE
      C ***** CALL VPROP(SN2,0) *****
          CALL VPROP(SN2,SN2,16,1530,16)
          DO 890 KK = 1,1536
285              SN1(KK+J) = SN1(KK+J)*SN2(KK)

```

```

      890      CONTINUE
            J = J + 1536
      500      CONTINUE
C ***** MAIN LOOP STARTS *****
290 C ***** CALL DBVXTOV(X*02,0,KJNF,0,DB,0,0 JNA)
      DO 707 KK = 1,24576
        JN(KK)=JN(KK)*SN1(KK)
      707      CONTINUE
            J = 1
295      DO 991 K = 1,3072
          DO 992 I = 1,16
            JNA(J) = JN(JNF(K)+I)
            J = J + 1
          992      CONTINUE
310      991      CONTINUE
C ***** CALL      *Z( Z      KJNS      DC      1)
            J = 1
            DO 993 K = 1,1536
              DO 994 I = 1,17
                JN1(J) = JNA(JNS(K)+I)
                J = J + 1
              994      CONTINUE
            993      CONTINUE
            JN1(26113) = 0.0
310      DO 900 KK = 1,26112
          JNA(KK) = JN1(KK+1) - JN1(KK)
          JNA(KK) = DEL J(KK)*JNA(KK)
          JN1(KK) = JN1(KK) + JNA(KK)
        900      CONTINUE
315      CALL PRVEC(4HJN1 , JN1)
            I7 = 1
            DO 902 KK = 1,26112
              IF (.NOT. 93(KK)) GO TO 902
              JNA(I7) = JN1(KK)
              JN1(I7) = JNA(I7)
              I7 = I7 + 1
            902      CONTINUE
C      WRITE(6,9998) JN1
            J = 0
325      I = 0
            DO 510 K = 1,16
              N = I + NTOM16
              DO 511 KK = 1,1536
                JNA(KK+N) = JN1(KK+J)
              511      CONTINUE
              DO 512 KK = 1,NTOM16
                JNA(KK+I) = JNA(KK+I+1536)
              512      CONTINUE
              DO 513 KK = 1,NTOM16
                JNA(N+1536+KK) = JN1(KK+J)
              513      CONTINUE
              J = J + 1536
              I = I + NT1536
            510      CONTINUE
340      CALL PRVEC(4HJNA , JNA)
            N = 0
            I1 = 0

```

```

      JK = 1
      DO 700 I = 1,16
345      I1=0
          DO 701 KK = 1,1536
              JN1(N+KK) = 0.0
701          CONTINUE
          DO 69J K = 1,16
350              J1 = NS + I1 - 1
              J2 = NS + I1 - 1
              DO 68J J = 1,NT1536
                  DO 703 KK = 1,1536
355                      JN(KK) = JNA(KK+J1) + JNA(KK+J2)
                      JN(KK) = JN(KK)*J(JK)
                      JN1(N+KK) = JN1(N+KK) + JN(KK)
703                  CONTINUE
                      JK = JK + 1
                      J1 = J1 + 16
                      J2 = J2 - 16
360                  CONTINUE
700          I1=I1+NT1536
              N = N + 1536
700          CONTINUE
365          CALL PRVEC(4HJN1T , JN1)
          C WRITE(6,9998) JN1
          CNORM = SUMLOG(JN1,24576)
          IF (CNORM.LT. 1.E-20) CNORM = 1.0
          CNORM = 1./CNORM
370          DO 710 KK = 1,24576
              JN(KK) = CNORM*JN1(KK)
              JNA(KK) = COSY(KK) * JN(KK)
710          CONTINUE
              CHAT = SUMLOG(JNA,24576)
375          DO 711 KK = 1,24576
              JNA(KK) = STNY(KK) * JN(KK)
711          CONTINUE
              SHAT = SUMLOG(JNA,24576)
              CXHAT = ATAN2(SHAT,CHAT)
380          J = 0
              DO 343 K = 1,16
                  DO 770 KK = 1,1536
                      YB(KK+J)=YC(K)
770                  CONTINUE
                      J = J + 1536
343                  CONTINUE
                      DO 771 KK = 1,24576
                          JNA(KK) = YB(KK)+JN(KK)
771                  CONTINUE
                      X3ESTO=X3EST
390                      X3EST = SUMLOG(JNA,24576)
                      DO 773 KK = 1,24576
                          JNA(KK) = JNA(KK)+YB(KK)
773                      CONTINUE
                          ALOSS=ALOSS
395                          ALOSS = SUMLOG(JNA,24576)
                          ALOSS = ALOSS - X3EST*X3EST
                          ALOSS=AMAX1(ALOSS,1.E-18)
          C ***** MAIN LOOP ENDS *****

```



```

400      CALL SECOND(TIMOUT)
        TNLF = TIMEOUT - TIMEIN
        WRITE(6,201) KOUNT,X1,X2,X3,SHAT,CHAT,CXHAT,X3EST,ALOSS
201      FORMAT( I5,1X,1P3E14.6,4X,1P2E14.6,4X,1P3E14.6 )
        WRITE(6,8880) TNLF
405      8880  FORMAT( 1P12.6 )
        IF (KOUNT.EQ. NO2 ) GO TO 505
        XDAT(KOUNT,2)=CXHAT
        XDAT(KOUNT,3)=ALOSS
        XDAT(KOUNT,4)=X3EST
410      KOUNT = KOUNT + 1
        GO TO 450
505      CONTINUE
        SUMP = 0.0
        SUMC = 0.0
415      XDAT(KOUNT,2) = CXHAT
        XDAT(KOUNT,3) = ALOSS
        XDAT(KOUNT,4) = X3EST
        DO 1501 I = 31,NO2
            XD = ABS(XDAT(I,1) - XDAT(I,2))
420      1498  CONTINUE
            IF (XD.GT. PI) GO TO 1499
            GO TO 1500
1499      XD = XD - PI2
            GO TO 1498
425      1500  SUPP = SUMP + XD*XD
1501      CONTINUE
        H = NO2 - 30
        SUMP = SUMP/H
        XNSAMP = NSAMP
430      XAA = XNSAMP + 1.0
        SUMP1 = (SUMP + XNSAMP*SUMP1)/XAA
        DSUMP1 = ALOG10(SUMP1)*10.0
        DO 1601 I = 31,NO2
            XD=ABS(XDAT(I,5)-XDAT(I,4))
435      1698  CONTINUE
            IF (XD.GT. PI) GO TO 1699
            GO TO 1700
1699      XD = XD - PI2
            GO TO 1698
440      1700  SUMC = SUMC + XD*XD
1601      CONTINUE
        SUMC = SUMC/H
        SUMP2 = (SUMC + XNSAMP*SUMP2)/XAA
        DSUMP2 = ALOG10(SUMP2)*10.0
445      WRITE(6,1511) NSAMP,SUMP1,DSUMP1,SUMP2,DSUMP2
        NSAMP = NSAMP + 1
        IF (ISAMP.EQ. NO3) GO TO 2200
        ISAMP = ISAMP + 1
        GO TO 71
450      2200  CONTINUE
        STOP
        6889  FORMAT(1H ,2(1E14.7,/,1H ) )
        9671  FORMAT(1H , I2)
        1511  FORMAT( I10,1P4E14.6,1H )
455      END

```

```

1          SUBROUTINE VPROP(FROM,TO,IGO,IEND,INC)
            DIMENSION FROM(1),TO(1)
            LEVEL 2, FROM, TO
            DO 10 I = IGO, IEND, INC
5              DO 20 J = 1, INC
                TO(I+J) = FROM(J)
            20      CONTINUE
C          10      CONTINUE
10         RETURN
C
            END

```

## SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS	DEF LINE	REFERENCES
3 VPROP	1	10

VARIABLES	SN	TYPE	RELOCATION	REFS			
0 FROM		REAL	ARRAY F.P.	REFS	2	3	6
36 I		INTEGER		REFS	6	DEFINED	4
0 IEND		INTEGER	F.P.	REFS	4	DEFINED	1
0 IGO		INTEGER	F.P.	REFS	4	DEFINED	1
0 INC		INTEGER	F.P.	REFS	4	5	DEFINE
37 J		INTEGER		REFS	2*6	DEFINED	5
0 TO		REAL	ARRAY F.P.	REFS	2	3	DEFINE

STATEMENT LABELS	DEF LINE	REFERENCES
0 10	9	4
0 20	7	5

OCPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
20	10	* I	4 9	15R	NOT INNEP
25	20	J	5 7	4R	INSTACK

STATISTICS	PROGRAM LENGTH	
	530	43

FUNCTION SUMLOG

76/76 OPT=1

FTN 4.6+433A

```

1      FUNCTION SUMLOG(A,N)
      DIMENSION A(1)
      LEVEL 2,A
      SUMLOG = 0.0
5      DO 10 I = 1,N
          SUMLOG = SUMLOG + A(I)
      10 CONTINUE
      C
      RETURN
10     C
      END
  
```

# SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS	DEF LINE	REFERENCES
4 SUMLOG	1	9

VARIABLES	SN	TYPE	RELOCATION	DEFS	REFS	DEFINED
0 A		REAL	ARRAY F.P.	2	3	
20 I		INTEGER		6	5	DEFINED
0 N		INTEGER	F.P.	5	5	DEFINED
17 SUMLOG		REAL		5	5	DEFINED

STATEMENT LABELS	DEF LINE	REFERENCES
0 10	7	5

LOOPS	LABEL	INDEX	FROM-TO	LENGTH	PROPERTIES
12	10	I	5 7	48	INSTACK

STATISTICS	PROGRAM LENGTH	218	17
------------	----------------	-----	----



```

1      SUBROUTINE GAUSS(JS,SD,XM,Y)
      DIMENSION NST(3)
      COMMON /RN/ N1,N2,N3,MC,T1,T2,T3
      COMMON /GN/ J, XR(2)
5      IF (J) 10, 10, 20
      10 J = 2
      TWOPI = 8.*ATAN(1.)
      NST(1) = 1609
      NST(2) = 2329
10     NST(3) = 1297
      XR(1) = PNPF(NST,1)
      GO TO 35
      20 GO TO (30,40), J
      30 J = 2
      15 XR(1) = PNPF(NST,3)
      35 XR(2) = PNPF(NST,6)
      X1 = SQRT(ABS(-2.*ALOG(XP(1))))
      XR(2) = TWOPI*XP(2)
      XR(1) = X1*SIN(XR(2))
20     XR(2) = X1*COS(XR(2))
      X = XP(1)*SD + XM
      RETURN
      40 J = 1
      X = XR(2)*SD+XM
25     RETURN
      END

```

CARD NR. SEVERITY DETAILS DIAGNOSIS OF PROBLEM

13 I

AN IF STATEMENT MAY BE MORE EFFICIENT THAN A 2 OR 3 BRAN

## SYMBOLIC REFERENCE MAP (P=3)

ENTRY POINTS	DEF LINE	REFERENCES
1 GAUSS	1	22 25

VARIABLES	SN	TYPE	RELOCATION	REFS	DEFINED
0 J		INTEGER	GN	4	5
0 JS		INTEGER	*UNUSED F.P.	1	
3 MC		INTEGER	PN	3	
77 NST		INTEGER	APRAY	2	11
0 N1		INTEGER	PN	3	
1 N2		INTEGER	PN	3	
2 N3		INTEGER	PN	3	
0 SD		REAL	F.P.	21	24
75 TWOPI		REAL		19	DEFINED
4 T1		REAL	PN	3	
5 T2		REAL	PN	3	
6 T3		REAL	PN	3	

```

1      FUNCTION RNNF(NS,MODE)
      DIMENSION NC(3),NS(3)
      COMMON /PN/ N1,N2,N3,MP,T1,T2,T3
      DATA M1,M2,M3 /3823,4006,2903/
5      IF (MODE) 10, 100, 10
      10 N1 = NS(1)
      N2 = NS(2)
      N3 = NS(3)
      T1 = 2.**(-12)
10     T2 = 2.**(-24)
      T3 = 2.**(-36)
      MP = 2**12
      100 K = N3*M3
      KD = K / MP
15     NC1 = K - KD*MP
      K = N3*M2 + N2*M3 + KD
      KD = K / MP
      NC2 = K - KD*MP
      K = N3*M1 + N2*M2 + N1*M3 + KD
20     KD = K / MP
      NC3 = K - KD*MP
      N1 = NC3
      N2 = NC2
      N3 = NC1
25     XN1 = N1
      XN2 = N2
      XN3 = N3
      RNNF = XN1*T1 + XN2*T2 + XN3*T3
      RETURN
30     END

```

## SYMBOLIC REFERENCE MAP (P=3)

ENTRY POINTS		DEF LINE		REFERENCES				
4 RNNF		1		29				
VARIABLES		SN	TYPE	RELOCATION				
63 K			INTEGER		DEFS	14	15	1
					DEFINED	17	16	1
64 KD			INTEGER		DEFS	15	16	1
					DEFINED	14	17	2
0 MODE			INTEGER	F.P.	DEFS	5	DEFINED	
3 MP			INTEGER	PN	DEFS	3	14	1
					DEFINED	12		
56 M1			INTEGER		DEFS	19	DEFINED	1
57 M2			INTEGER		DEFS	16	10	DEFINED
60 M3			INTEGER		DEFS	13	16	1
73 NC			INTEGER	*UNDEF	DEFS	2		
65 NC1			INTEGER		DEFS	24	DEFINED	1
66 NC2			INTEGER		DEFS	27	DEFINED	1
67 NC3			INTEGER		DEFS	22	DEFINED	2
0 NS			INTEGER	ARRAY	DEFS	2	6	
0 N1			INTEGER	PN	DEFS	3	10	2

```

1      SUBROUTINE PRVEC(LABEL,VEC)
      C PRINT SELECTED VECTOR COMPONENTS
      INTEGER LABEL,DIM12,COUNT
      REAL VEC(1)
5      LEVEL 2,VEC
      DATA DIM12,COUNT/1536, 0/
      COUNT = COUNT+1
      C WRITE(6,99) COUNT, LABEL.
      C * VEC(DIM12*7 + 1), VEC(DIM12*7+750),
13      C * VEC(DIM12*7+1148)
      C 99 FORMAT(11H PR. ENTRY ,15,9H AT ENT. ,A4,
      C * 5E14.7)
      RETURN
      END

```

## SYMBOLIC REFERENCE MAP (R=3)

ENTRY POINTS	DEF LINE	REFERENCES
3 PRVEC	1	17

VARIABLES	SN	TYPE	RELOCATION	REFS		7	DEFINE
10 COUNT		INTEGER		REFS	3	DEFINED	6
7 DIM12		INTEGER		REFS	3	DEFINED	1
0 LABEL		INTEGER	*UNUSED F.P.	REFS	3	DEFINED	1
0 VEC		REAL	ARRAY F.P.	REFS	4	5	DEFINT

STATISTICS



The code for the 3-D phase demodulation problem was a natural extension of that for the 2-D problem described earlier. The model for the problem is described in [1]. In particular the problem pushed the capacity of Star to its limit as the density now was represented as a 25,000 word vector which because of the algorithm structure required close to the 65,000 word vector limit of the machine. This code was not used for Monte Carlo production runs because of computer time limitations, but as a check on the accuracy of the assembly code for the AP120B code of the next section.

```

00001      PROGRAM MAIN(INPUT,OUTPUT,PUNCH,UNIT6=OUTPUT,UNIT5=INPUT,
X          UNIT10=SEED)
00002      DIMENSION XDAT(130,10),XHAT(4),Y1(35),Y2(135),
*EXPON(35),EXDON(17),Y3(17),PNF(3,3) ,YA(35),EXP33(16,16),
*Q(3,3),PBAR(3,3),PN(3,3),AN(3),F(3,3),PDUMMY(3,3),PDUMY2(3,3)
00003      COMMON/GN/JGAUSS,XZZZ(2)
00004      REAL COSY(24576),SINY(24576),SN1(24576),SN2(1536),JN(24576),
*JN1(26112),JNA(54272),DELJ(26112),S1(16),S2(16),YB(24576),D(2000)
00005      REAL YC(16)
00006      INTEGER JNS(1536),JNF(3072)
00007      INTEGER OPSEED,SDNORM,SDWRT,SDRDWR,SDSTAR,SDRUN,SDSAVE,SDREST
00008      BIT B3(26112)
00009      DESCRIPTOR DB,KJNF,DJNA,KJNS,DJN1,DC
00010      DATA SDNORM,SDWRT,SDRDWR, SDSTAR,SDRUN,SDSAVE,SDREST
X          /0,1,2, 1,2,3,4/
00011      NAMELIST /INSTR/ Y3EST,Q33C,ALF,GAM,NUM3,
X          Y1EST,Y2EST,ALP110,DELF,Q22C,NUM1,NUM2,NO2,NO3,OPSEED,
X          IPRIN
00012      ASSIGN DB,JN(1;16)
00013      ASSIGN KJNF,JNF(1;3072)
00014      ASSIGN DJNA,JNA(1;49152)
00015      ASSIGN KJNS,JNS(1;1536)
00016      ASSIGN DJN1,JN1(1;26112)
00017      ASSIGN DC,JNA(1;17)
00018      CALL Q3CLOCKS(IDATE,ITIME)
00019      WRITE(6,992) IDATE,ITIME
00020      992 FORMAT(' COMPILE VERSION 5-18-77, NEW FILT34',
X          ' . DATE,TIME = ',2A12)
00021      JGAUSS=0
C      SET SEED DEFAULT
00022      OPSEED = SDNORM
00023      JSEED = SDRUN
00024      IPRIN = 2
C63      FORMAT(4F10.5,15)
00025      READ(5,INSTR)
00026      WRITE(5,INSTR)
C64      FORMAT(5F10.5,4I5)
C
00027      IF(OPSEED .EQ. SDRDWR) GOTO 31
00028      CALL GAUSS(SDSTAR, TEM1,TEM2,TEM3)
00029      GOTO 32
00030      31 CONTINUE
00031      CALL GAUSS(SDREST, TEM1,TEM2,TEM3)
00032      32 CONTINUE
C

```

```
00033 P110=10.** (ALP110/10.)
00034 QQ=Q22C** (.25)
00035 RX=(P110/(SQRT(2.0)*QQ))** (4.0/3.0)
00036 FTC=SQRT(2.0)*RX** (.25)/QQ
00037 DELT=DELF*FTC
00038 Q22=Q22C*DELT
00039 R11=RX/DELT
00040 R11M1 = 1./R11
00041 P220=P110*SQRT(Q22C/RX)
00042 ALFD=ALF*DELT
00043 BET=1.0-ALFD
00044 A11=10.** ((ALP110+GAM)/10.)
00045 A22=P220
00046 P330=0.5*Q33C/ALF
00047 A33=2.0*P330
00048 Q33=Q33C*DELT
00049 DEV1=SQRT(A11)
00050 DEV2=SQRT(A22)
00051 DEV3=SQRT(R11)
00052 DEV4=SQRT(A33)
00053 DEVQ2=SQRT(Q22)
00054 DEVQ3=SQRT(Q33)
00055 KOUNT=1
00056 ISAMP=1
00057 NSAMP=0
00058 SUMP1=0.0
00059 SUMP2=0.0
00060 SUMP3=0.0
00061 DELSQ=DELT**2
00062 PI=4.*ATAN(1.)
00063 PI2=2.0*PI
00064 PIDLT=PI/DELT
00065 PINV=1.0/PI
00066 PI2DLT=2.0*PIDLT
00067 U1=NUM1
00068 U2=NUM2
00069 U3=NUM3
00070 IY2=U2/PI2DLT*SQRT(50.0*Q22)+.5
00071 NTERM=IY2
00072 NTERM1=NTERM+1
00073 NTERM16=NTERM*16
00074 NC=NTERM16+1
00075 NT=2*NTERM16
00076 NTA1536=NT+1536
00077 R55=0.5/R11
```



```

00078      CL=-0.5/A22
00079      CM=-0.5/A33
00080      SI=-0.5/A11
      C      *****GRID Y1,Y2 AND YA *****
00081      EDG1=PI/U1
00082      EDG2=PI*DLT/U2
00083      DO 40 I=1,NUM1
00084          X=I-1
00085          X=X/U1
00086      40      Y1(I)=-PI+X*PI2+EDG1
00087      DO 50 I=1,NUM2
00088          X=I-1
00089          X=X/U2
00090      50      Y2(I)=-PI*DLT+X*PI2*DLT+EDG2
00091      DO 51 I=1,IY2
00092          X=I
00093          X=X/U2
00094      51      Y3(I)=X
00095      DO 55 I=1,NUM1
00096          COSY(I)=COS(Y1(I))
00097      55      SINY(I)=SIN(Y1(I))
00098          S1(1;16)=COSY(1;16)/R11
00099          S2(1;16)=SINY(1;16)/R11
00100          CALL VPROP(SINY,1)
00101          CALL VPROP(COSY,1)
      C      BEGIN NEW SAMPLE PATH
00102      71      XP=0.5*SQRT(A33)
00103          YY3=(NUM3-1.0)/2.0+1.0
00104          IY3=YY3
      C
00105          IF(I*PRIN .GE. 2)
      X      WRITE(6,981)
00106      981      FORMAT('1  KOUNT,X1,X2,X3,  Z1,Z2,  ',
      X      /' CXHAT,X3EST,ALOSS,  TNL')
00107          DO 60 I=1,NUM3
00108              XX=I-YY3
00109              YC(I)=Y3EST+XP*XX
00110      60      YA(I)=Y3EST+XP*XX
      C      ***** DYNAMIC EXPONENTIALS *****
00111          IF(IY2.EQ.0)GO TO 153
00112          DO 150 I=1,IY2
00113              DON=PI*DLT*PI2*DLT
00114      150      EXDON(I)=EXP(-DON/Q22*(Y3(I)**2))
00115          DO 152 I=1,IY2
00116              EXPON(I)=EXDON(IY2+1-I)

```

FORTRAN R1.3 CYCLE I      BUILT 09/27/78 20:40      SOURCE LISTING      MAIN

```

00117      152      EXPON(IY2+1+I)=EXPON(I)
00118      153      EXPON(IY2+1)=0.5
00119              IYY=2*IY2+1
00120              LTERM2=0
00121              DO 720 K=1,16
00122              DO 720 I=1,16
00123              XNUM=(K-I)*XP+ALFD*(YA(I)-1.)
00124              XNUM=-0.5/Q33*XNUM**2
00125              EXP33(I,K)=0.0
00126              IF(XNUM.LT.-27.)GO TO 720
00127              EXP33(I,K)=EXP(XNUM)
00128      720      CONTINUE
00129              LTERM=0
00130              LTERM16=LTERM*16
00131              LTERM1=LTERM+1
00132              LC=LTERM16+1
00133              NS=NTA1536*LTERM+NC
00134              I=0
00135              DO 339 K=1,16
00136              DO 339 N=1,16
00137              DO 339 J=NTERM1,IYY
00138              I=I+1
00139      339      D(I)=EXPON(J)*EXP33(N,K)
00140              ALOSS=A33
00141              ALOSSO=ALOSS
00142              X3EST = Y3EST
00143              X3ESTO = Y3EST
C          ***** INITIAL DENSITY *****
00144              IJK=0
00145              DO 160 K=1,16
00146              ZZZ=CM*(YA(K)-Y3EST)**2
00147              DO 160 J=1,96
00148              YYY=ZZZ+CL*(Y2(J)-Y2EST)**2
00149              DO 160 I=1,16
00150              IJK=IJK+1
00151              XXX=YYY+SI*(Y1(I)-Y1EST)**2
00152              IF(XXX.LT.-27.)GO TO 159
00153              JN(IJK)=EXP(XXX)
00154              GO TO 160
00155      159      JN(IJK)=0.0
00156      160      CONTINUE
C          ***** INTEGER ARRANGEMENT *****
00157              DO 225 I=1,26112
00158      225      B3(I)=B'1'
00159              I=0

```

FORTRAN 21.3 CYCLE I

BUILT 09/27/78 20:40

SOURCE LISTING

MAIN

```

00160      DO 300 K=1,16
00161      DO 300 J=1,96
00162      I=I+17
00163      300  B3(I)=B*0
00164      DO 320 K=1,3071,2
00165      JNF(K)=(K-1)*8
00166      320  JNF(K+1)=JNF(K)
00167      I=0
00168      J1=0
00169      DO 332 K=1,16
00170      DO 332 J=1,96
00171      I=I+1
00172      I1=J1+MOD(23-(J-1)/6,16)
00173      JNS(I)=I1
00174      332  J1=J1+32
00175      DELJ(1;17)=11./12.
00176      DELJ(18;17)=0.75
00177      DELJ(35;17)=7./12.
00178      DELJ(52;17)=5./12.
00179      DELJ(69;17)=0.25
00180      DELJ(86;17)=1./12.
00181      CALL VPROP1(DELJ)
00182      11  CONTINUE
00183      KOUNT=1
00184      CALL GAUSS(JSEED,DEV1,Y1EST,X1)
00185      XDAT(KOUNT,1)=X1
00186      CALL GAUSS(JSEED,DEV2,Y2EST,X2)
00187      CALL GAUSS(JSEED,DEV4,Y3EST,X3)
00188      ACOS=X3*COS(X1)
00189      ASIN=X3*SIN(X1)
00190      CALL GAUSS(JSEED,DEV3,ACOS,Z1)
00191      CALL GAUSS(JSEED,DEV3,ASIN,Z2)
00192      GO TO 470
00193      450  CONTINUE
00194      X1=X1+X2*DELT
00195      XDAT(KOUNT,1)=X1
00196      CALL GAUSS(JSEED,DEVQ2,X2,X2)
00197      X3=X3*BET+ALFD
00198      CALL GAUSS(JSEED,DEVQ3,X3,X3)
00199      XDAT(KOUNT,5)=X3
00200      ACOS=X3*COS(X1)
00201      ASIN=X3*SIN(X1)
00202      CALL GAUSS(JSEED,DEV3,ACOS,Z1)
00203      CALL GAUSS(JSEED,DEV3,ASIN,Z2)
C      XP=0.5*AMAX1(.001,SQRT(ALOSS))

```



```

00204      XP=.5*SQRT(ALOSS)
00205      XPD=.5*SQRT(ALOSSD)
C      XPD=.5*AMAX1(.001,SQRT(ALOSSJ))
00206      DO 600 I=1,NUM3
00207          XX=I-YY3
00208          YA(I)=X3ESTO+XX*XPD
00209      600 CONTINUE
00210      DO 730 K=1,16
00211      DO 730 I=1,16
00212          XNUM=-YA(I)+X3EST+XP*(K-YY3)+ALFD*(YA(I)-1.)
00213          XNUM=-0.5/Q33*XNUM**2
00214          EXP33(I,K)=0.0
00215          IF(XNUM.LT.-27.)GO TO 730
00216          EXP33(I,K)=EXP(XNUM)
00217      730 CONTINUE
00218          I=0
00219          DO 340 K=1,16
00220          DO 340 N=1,16
00221          DO 340 J=NTERM1,IYY
00222              I=I+1
00223      340      D(I)=EXPON(J)*EXP33(N,K)
00224      470 CONTINUE
C      ***** SENSOR FUNCTION *****
00225      CALL Q3CLOCK(S,T,TT)
00226      R11TZ1 = Z1*R11M1
00227      R11TZ2 = Z2*R11M1
00228      S1(1;16) = R11TZ1*COSY(1;16)
00229      S2(1;16) = R11TZ2*SINY(1;16)
00230      S1(1;16)=S1(1;16)+S2(1;16)
00231      J=1
00232      DO 500 K=1,16
00233          S2(1;16)=S1(1;16)*(X3EST+(K-YY3)*XP)
00234          SN2(1;16)=VEXP(S2(1;16);SN2(1;16))
00235          CALL VPROP(SN2,0)
00236          SN1(J;1536)=SN2(1;1536)
00237          S2(1;16)=-R55*(X3EST+(K-YY3)*XP)*(X3EST+(K-YY3)*XP)
00238          SN2(1;16)=VEXP(S2(1;16);SN2(1;16))
00239          CALL VPROP(SN2,0)
00240          SN1(J;1536)=SN1(J;1536)+SN2(1;1536)
00241      500      J=J+1536
C      ***** MAIN LDOPOSTARTS *****
00242      JN(1;24576)=JN(1;24576)*SN1(1;24576)
00243      CALL Q3VXTDV(X'02',0,KJNF,0,JB,0,DJNA)
00244      CALL Q8VXTDV(X'02',0,KJNS,0,JC,0,DJN1)
00245      JNA(1;26112)=JN1(2;26112)-JN1(1;26112)

```

FORTTRAN R1.3 CYCLE I

BUILT 09/27/78 20:40

SOURCE LISTING

MAIN

```

00246      JNA(1;26112)=DEL J(1;26112)*JNA(1;26112)
00247      JN1(1;26112)=JN1(1;26112)+JNA(1;26112)
00248      CALL PRVEC('JN1', JN1)
00249      JNA(1;24576)=Q8VCMPRS(JN1(1;26112),B3(1;26112);JNA(1;24576))
00250      JN1(1;24576)=JNA(1;24576)
00251      J=1
00252      I=1
00253      DO 510 K=1,16
00254      N=I+NTERM16
00255      JNA(N;1536)=JN1(J;1536)
00256      JNA(I;NTERM16)=JNA(I+1536;NTERM16)
00257      JNA(N+1536;NTERM16)=JN1(J;NTERM16)
00258      J=J+1536
00259      510 I=I+NTA1536
00260      N=1
00261      I1=0
00262      JK=1
00263      CALL PRVEC('JNA', JNA)
00264      DO 700 I=1,16
00265      I1=0
00266      JN1(N;1536)=0.0
00267      DO 690 K=1,16
00268      J1=NS+I1
00269      J2=NS+I1
00270      DO 680 J=1,NTERM1
00271      JN1(1;1536)=JNA(J1;1536)+JNA(J2;1536)
00272      JN(1;1536)=JN(1;1536)*D(JK)
00273      JN1(N;1536)=JN1(N;1536)+JN(1;1536)
00274      JK=JK+1
00275      J1=J1+16
00276      680 J2=J2-16
00277      690 I1=I1+NTA1536
00278      N=N+1536
00279      700 CONTINUE
00280      CALL PRVEC('JN1T', JN1)
00281      CNORM=SUMLOG(JN1)
00282      IF(CNORM.LT.1.0E-20)CNORM=1.0
00283      CNORM=1./CNORM
00284      JN(1;24576)=CNORM*JN1(1;24576)
00285      SHAT = 0.
00286      CHAT = 0.
00287      SUMSC = 0.
C 3-2-77
00288      DO 751 I=1,16
00289      SUMSC = 0.

```

```

00290      DO 729 J=1,96
00291      DO 729 K=1,16
00292
00293          ITEMP = I+16*(J-1)+1536*(K-1)
00294          SUMSC = SUMSC+JN(ITEMP)
00295      729  CONTINUE
00296          CHAT = CHAT+SUMSC*COSY(I)
00297          SHAT = SHAT+SUMSC*SINY(I)
00298      751  CONTINUE
C          JNA(1;24576)=COSY(1;24576)*JN(1;24576)
C          CHAT=SUMLOG(JNA)
C          JNA(1;24576)=SINY(1;24576)*JN(1;24576)
C          SHAT=SUMLOG(JNA)
00299      CXHAT=ATAN2(SHAT,CHAT)
00300      J=1
00301      DO 343 K=1,16
00302      YB(J;1536)=(X3EST+(K-YY3)*XP)
00303      343  J=J+1536
00304          JNA(1;24576)=YB(1;24576)*JN(1;24576)
00305          X3ESTO=X3EST
00306          X3EST=SUMLOG(JNA)
00307          JNA(1;24576)=JNA(1;24576)*YB(1;24576)
00308          ALOSSO=ALOSS
00309          ALOSS=SUMLOG(JNA)
00310          ALOSS=AMAX1(ALOSS-X3EST*X3EST,1.E-18)
C          ***** MAIN LOOP ENDS *****
00311      CALL Q3CLOCKS(TNLF,TT)
00312      IF(IPRIN .GE. 2)
X          WRITE(6,201)KOUNT,X1,X2,X3,Z1,Z2,CXHAT,X3EST,ALOSS
00313      201  FORMAT(1H , 15,1X,1P3E14.6,4X,1P2E14.6,4X,1P3E1+.6 )
00314      IF(IPRIN .GE. 2)
X          WRITE(6,8880)TNLF
00315      8880  FORMAT(1H ,1PE12.6)
00316      IF(KOUNT.EQ.NO2)GO TO 505
00317      XDAT(KOUNT,2)=CXHAT
00318      XDAT(KOUNT,3)=ALOSS
00319      XDAT(KOUNT,4)=X3EST
00320      KOUNT=KOUNT+1
00321      GO TO 450
00322      505  CONTINUE
00323      SUMP=0.0
00324      SUMC=0.0
00325      XDAT(KOUNT,2)=CXHAT
00326      XDAT(KOUNT,3)=ALOSS
00327      XDAT(KOUNT,4)=X3EST

```



```

00328      DO 1501 I=31,N02
00329          XD=ABS(XDAT(I,1)-XDAT(I,2))
00330      1498 CONTINUE
00331          IF(XD.GT.PI)GO TO 1499
00332      GO TO 1500
00333      1499 XD=XD-PI2
00334      GO TO 1498
00335      1500 SUMP=SUMP+XD**2
00336      1501 CONTINUE
00337          H=N02-30
00338          SUMP=SUMP/H
00339          XNSAMP=NSAMP
00340          XAA=XNSAMP+1.0
00341          SUMP1=(SUMP+XNSAMP*SUMP1)/XAA
00342          DSUMP1=ALOG10(SUMP1)*10.0
00343      DO 1601 I=31,N02
00344          XD=ABS(XDAT(I,5)-XDAT(I,4))
00345      1698 CONTINUE
00346          IF(XD.GT.PI)GO TO 1699
00347      GO TO 1700
00348      1699 XD=XD-PI2
00349      GO TO 1698
00350      1700 SUMC=SUMC+XD**2
00351      1601 CONTINUE
00352          SUMC=SUMC/H
00353          SUMP2=(SUMC+XNSAMP*SUMP2)/XAA
00354          DSUMP2=ALOG10(SUMP2)*10.0
00355          WRITE(6,1511)NSAMP,SUMP1,DSUMP1,SUMP2,DSUMP2
00356      1511 FORMAT(1H ,I10,1P4E14.6)
00357          NSAMP=NSAMP+1
C
C      OPTIONAL SAVE OF SEED
00358      IF( (OPSEED .EQ. SDWRT) .OR. (OPSEED .EQ. SORDWR))
X      CALL GAUSS(SDSAVE, TEM1,TEM2,TEM3)
C
00359      IF(ISAMP .EQ. N03) GO TO 2200
00360      ISAMP = ISAMP+1
00361      GO TO 71
00362      2200 CONTINUE
C
00363      STOP
00364      END

```

FORTRAN R1.3 CYCLE I      BUILT 09/27/78 20:40      SOURCE LISTING

```
00001      FUNCTION SUMLOG(A)
00002      REAL A(26112),C(12288)
00003      C(1;12288)=A(1;12288)+A(12289;12288)
00004      C(1;6144)=C(1;6144)+C(6145;6144)
00005      C(1;3072)=C(1;3072)+C(3073;3072)
00006      C(1;1536)=C(1;1536)+C(1537;1536)
00007      C(1;768)=C(1;768)+C(769;768)
00008      C(1;384)=C(1;384)+C(385;384)
00009      C(1;192)=C(1;192)+C(193;192)
00010      C(1;96)=C(1;96)+C(97;96)
00011      C(1;48)=C(1;48)+C(49;48)
00012      C(1;24)=C(1;24)+C(25;24)
00013      C(1;12)=C(1;12)+C(13;12)
00014      C(1;6)=C(1;6)+C(7;6)
00015      C(1;3)=C(1;3)+C(4;3)
00016      SUMLOG=C(1)+C(2)+C(3)
00017      RETURN
00018      END
```

FORTRAN R1.3 CYCLE I

BUILT 09/27/78 20:40

SOURCE LISTING

```
00001  SUBROUTINE VPROP(A,I)
00002  REAL A(24576)
00003  IF(I.EQ.2)GO TO 10
00004  A(17;16)=A(1;16)
00005  A(33;32)=A(1;32)
00006  A(65;32)=A(1;32)
00007  10  A(97;96)=A(1;96)
00008  A(193;192)=A(1;192)
00009  A(385;384)=A(1;384)
00010  A(769;768)=A(1;768)
00011  IF(I.EQ.0)RETURN
00012  A(1537;1536)=A(1;1536)
00013  A(3073;3072)=A(1;3072)
00014  A(6145;6144)=A(1;6144)
00015  A(12289;12288)=A(1;12288)
00016  RETURN
00017  END
```



FORTRAN R1.3 CYCLE I

BUILT 09/27/78 20:40

SOURCE LISTING

```
00001      SUBROUTINE VPROP1(A)
00002      REAL A(26112)
00003      A(103;102)=A(1;102)
00004      A(205;204)=A(1;204)
00005      A(409;408)=A(1;408)
00006      A(817;816)=A(1;816)
00007      A(1633;1632)=A(1;1632)
00008      A(3265;3264)=A(1;3264)
00009      A(6529;6528)=A(1;6528)
00010      A(13057;13056)=A(1;13056)
00011      RETURN
00012      END
```

FORTRAN R1.3 CYCLE I      BUILT 09/27/78 20:40      SOURCE LISTING

```
00001      FUNCTION RNNF(NS,MODE)
00002      DIMENSION NS(2), NC(2)
00003      COMMON /RN/ N1, N2, MP, T1, T2
00004      DATA M1, M2/244734, 158551/
       C      MODE=0 TO CONTINUE, OTHERWISE RESTART WITH
       C      INTEGER NUMBER NS(1)*2**18+NS(2)
00005      IF (MODE) 10, 100, 10
00006      10 N1=NS(1)
00007      N2=NS(2)
00008      T1=2.**(-18)
00009      T2=2.**(-36)
00010      MP=2**18
00011      RETURN
       C
00012      100 DO 200 I=1,2
00013      GO TO (110,120),I
00014      110 K=M2*N2
00015      GO TO 190
00016      120 K=M1*N2+M2*N1+KD
00017      190 KD=K/MP
00018      200 NC(I)=K-KD*MP
00019      N1=NC(2)
00020      N2=NC(1)
00021      XN1=N1
00022      XN2=N2
00023      RNNF=XN1*T1+XN2*T2
00024      RETURN
00025      END
```

FORTRAN R1.3 CYCLE I            BUILT 09/27/78 20:40            SOURCE LISTING

```
00001        SUBROUTINE GAUSS(JS,SD,XM,X)
00002        DIMENSION NST(2)
00003        COMMON /RN/ N1, N2, MC, T1, T2
00004        COMMON /GN/ J,XR(2)
C        SELECT RESTART,RUN,SAVE,RESTORE
C
00005        GOTO (10, 20, 101, 201),JS
00006        10 J=1
00007        TWOPI=8.*ATAN(1.)
00008        NST(1)=244734
00009        NST(2)=158551
00010        NST(1)=102943
00011        NST(2)=185617
00012        XR(1)=RNNF(NST,1)
00013        RETURN
C
C        RUN (GENERATE RANDOM NO.)
00014        20 GO TO (30,40), J
00015        30 J=2
00016        XR(1)=RNNF(NST,0)
00017        35 XR(2)=RNNF(NST,C)
00018        X1=SQRT(ABS(-2.*ALOG(XR(1))))
00019        XR(2)=TWOPI*XR(2)
00020        XR(1)=X1*SIN(XR(2))
00021        XR(2)=X1*COS(XR(2))
00022        X=XR(1)*SD+XM
00023        RETURN
00024        40 J=1
00025        X=XR(2)*SD+XM
00026        RETURN
C
C        SAVE SEED
00027        101 REWIND 10
00028        WRITE(10,991) N1,N2,J,XR(2)
00029        WRITE(6,991) N1,N2,J,XR(2)
00030        RETURN
C
C        RESTORE SEED
00031        201 CONTINUE
00032        REWIND 10
00033        READ(10,991) NST(1),NST(2),J,XR(2)
00034        WRITE(6,991) NST(1), NST(2), J,XR(2)
00035        TWOPI = 8.*ATAN(1.)
00036        XR(1) = PNNF(NST,1)
00037        RETURN
```



FORTRAN R1.3 CYCLE I

BUILT 09/27/78 20:40

SOURCE LISTING

GAUSS

00036

00039

C

991 FORMAT(' RANDOM SEEDS ',3I10,E28.18)

END

FORTRAN R1.3 CYCLE I

BUILT 09/27/78 20:40

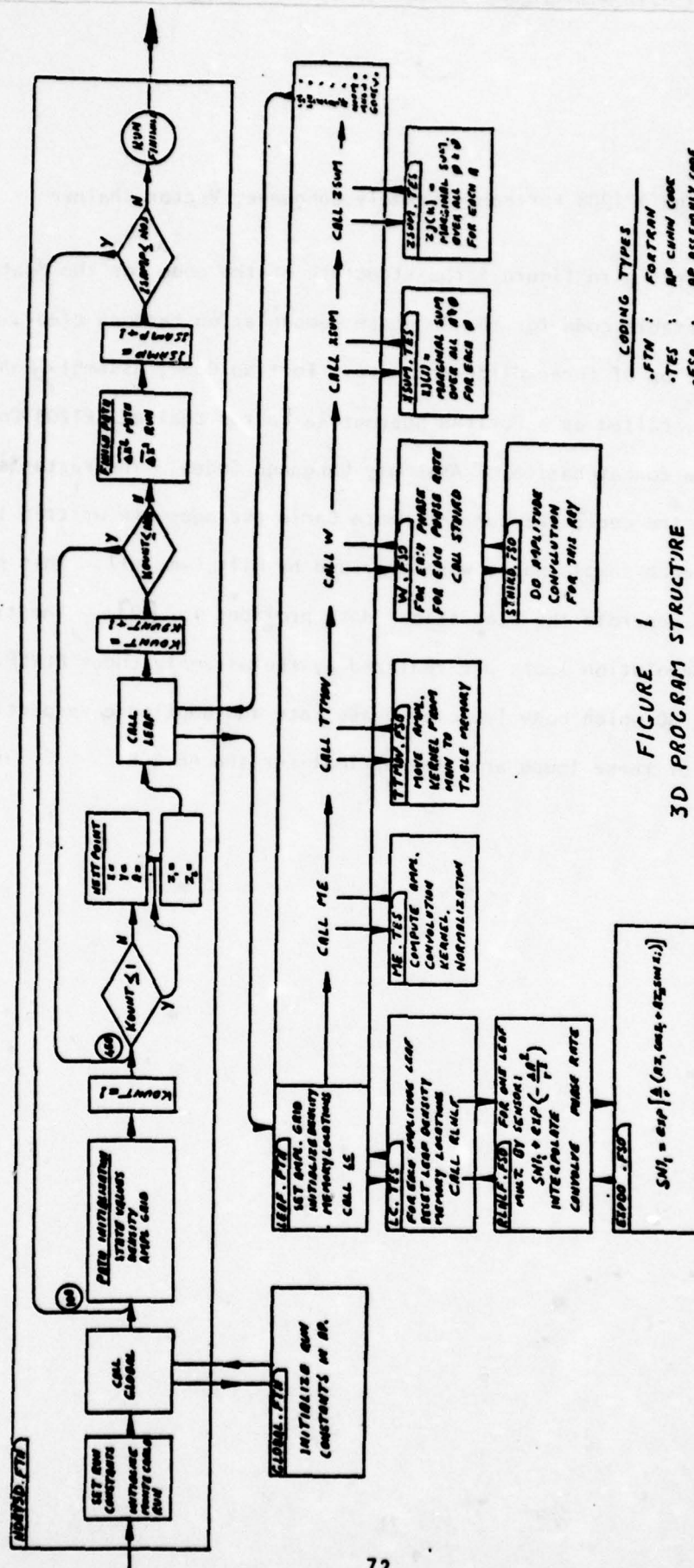
SOURCE LISTING

```
00001      SUBROUTINE PRVEC(LABEL,VEC)
          C  PRINT SELECTED VECTOR COMPONENTS
00002      INTEGER LABEL,DIM12,COUNT
00003      REAL VEC(1)
00004      DATA DIM12,COUNT/1536, 0/
00005      IF(COUNT.GE. 0) RETURN
00006      COUNT = COUNT+1
00007      WRITE(6,99) COUNT, LABEL,
          * VEC(DIM12*7+1), VEC(DIM12*7+760),VEC(DIM12*7+1148)
00008  99    FORMAT(' PR. ENTRY ',I5,' AT PNT. ',A4,
          * 5E14.7)
00009      RETURN
00010      END
```

### 11 - 3 The AP120B Fortran, Assembly Language, Vector Chainer

By referring to figure 1 the structure of the code for the Monte Carlo restartable code for the 3D phase demodulation becomes clear. The code is made up of three different types, Fortran Code, Assembly Language AP120B Code, called as a Fortran Subroutine Vector Chained AP120B Code, which is the concatenation of Assembly Language Codes. The restartable features of the code, the current Monte Carlo averages are written to a file after each sample path, were provided by Milt Campbell. This program was used to generate the statistical data provided in [2]. The time critical convolution loops are realized by the assembly codes RLNLF.FS0 and STHIRD.FS0 which convolve over phase rate and amplitude respectively. The coding of these loops are time optimal for the AP120B.





CODING TYPES

.FTH : FORTRAN

.TES : RP CMM CODE

.FSO : RP ASSEMBLY CODE

FIGURE 1  
3D PROGRAM STRUCTURE

THIS FILE CONTAINS INFORMATION ON HOW TO RUN EXGO.

M. CAMPBELL (SYSCON DESIGN)

OCTOBER 9, 1978

SECTIONS ARE PRECEDED BY A LINE

##N

WHERE N IS THE NUMBER. THIS ALLOWS EASY ACCESS VIA THE EDITOR.

CONTENTS.

- ##1-RUNNING THE PROGRAM
- ##2-LOOKING AT DATA FILES
- ##3-RECOVERING FROM ERRORS
- ##4-DATA FILE FORMAT
- ##5-FORTRAN SOURCE FILES
- ##6-COMMAND FILES

## ##1 RUNNING THE PROGRAM

##1.1 THE PROGRAM IS ON FILE EXGO.TSK SO IT MAY BE RUN AS A NORMAL RSX-11M PROGRAM. ON STARTUP THE PROGRAM EXPECTS THE FILES 'INITIAL.DAT' AND 'RESTART.DAT' TO BE PRESENT AND TO CONTAIN THEIR CORRECT VALUES (SEE DATA FILE STRUCTURE). 'INITIAL.DAT' CONTAINS DATA CONSTANT FOR A RUN AND ONCE EDITED TO YOUR SATISFACTION NEED NOT BE MODIFIED. 'RESTART.DAT' IS DYNAMICALLY UPDATED BY THE PROGRAM AND CONTAINS THE CURRENT RESTART INFORMATION. FOR THE INITIAL RUN OF THE PROGRAM ONLY!, FILE 'RESTART.INT' SHOULD BE COPIED TO 'RESTART.DAT' TO ENSURE THAT A RUN OF THE PROGRAM WILL INITIALIZE PROPERLY.

##1.2 COMMAND FILE 'NEWRUN.DAT' IS PROVIDED TO SET UP THE DATA FILES FOR INITIATING AN EXGO RUN. IT RENAMES ANY OLD RESTART FILES (WHICH CONTAIN FINAL RESULTS OF RUNS) TO BE 'RESTART.OLD', DELETES ANY EXISTING BACKUP FILES, CREATES AN INITIAL RESTART BY COPYING 'RESTART.INT' TO 'RESTART.DAT' AND EXITS. THE FILES ARE NOW READY FOR AN 'RUN EXGO' COMMAND.

##1.3 PROGRAM CTLXGO IS PROVIDED TO ALLOW ORDERLY SHUT DOWN OF EXGO EXTERNALLY. EXGO USES EVENT FLAG 54 FOR CONTROL. IF, AT THE END OF THE MAIN LOOP, THE EVENT FLAG IS SET, EXGO SHUTS DOWN WITH THE DATA FILES SET UP FOR RESTART.

## ##2. GETTING DATA

##2.1 RUNNING VALUES. THE FILE 'RESTART.DAT' ALWAYS CONTAINS THE RESULTS OF THE LAST TIME THROUGH THE OUTER LOOP OF EXGO. IT IS THIS FILE THAT WILL BE USED IF EXGO IS INTERRUPTED AND THEN RESTARTED. EXAMINING 'RESTART.DAT' COULD PROVIDE THE LATEST INFORMATION ON THE STATUS OF EXGO.

THE FILE 'BACKUP.DAT' CONTAINS THE SAME VALUES AS 'RESTART.DAT' BUT FROM THE PREVIOUS PASS THROUGH THE OUTER LOOP. THIS IS THE SECONDARY RECOVERY FILE IN CASE THERE IS SOME PROBLEM WITH 'RESTART.DAT'.

##2.2 START STATUS. A NEW VERSION OF 'RUNSTAT.DAT' IS CREATED EACH TIME EXGO IS STARTED AND ANYTIME THE PROGRAM FAILS

THIS PAGE IS BEST QUALITY FRAGMENTARY  
FROM COPY FURNISHED TO DDC

**#2.3 EXAMINING THE FILES.** 'RESTART.DAT' AND 'BACKUP.DAT' SHOULD BE EXAMINED ONLY WITH EXGO NOT RUNNING, SINCE EXGO WILL QUIT (WITH AN ERROR ON 'RUNSTAT.DAT') IF IT CAN NOT ACCESS BOTH FILES.

'RUNSTAT.DAT' MAY BE EXAMINED AT ANY TIME AS A NEW VERSION IS CREATED AS NEEDED.

**#3. RECOVERING FROM ERRORS.**

**#3.1** IF EXGO ATTEMPTS TO KEEP THE RESULTS OF THE LAST TIME THROUGH THE OUTER LOOP ON THE FILE 'RESTART.DAT' AND THE RESULTS ON THE PREVIOUS PASS ON 'BACKUP.DAT'. THE OLD DATA IS COPIED FROM 'RESTART.DAT' TO 'BACKUP.DAT' BEFORE WRITING THE NEW DATA TO 'RESTART.DAT'.

IF EXGO IS UNABLE TO ACCESS ANYONE OF 'INITIAL.DAT', 'RESTART.DAT' OR 'BACKUP.DAT', OR IF THERE IS SOME ERROR IN READING THEM (END-OF-FILE OR CONSISTENCY CHECK BAD), IT WRITES AN ERROR MESSAGE ON 'RUNSTAT.DAT' AND STOPS.

**#3.1** IF 'RESTART.DAT' IS BAD BUT 'BACKUP.DAT' IS GOOD, RENAME 'BACKUP.DAT' TO BE 'RESTART.DAT'. THIS RESULTS IN THE LOSS OF ONE PASS THROUGH THE OUTER LOOP.

**#3.2** IF BOTH 'RESTART.DAT' AND 'BACKUP.DAT' ARE BAD, THE LATEST 'RUNSTAT.DAT' CAN BE USED BY RENAMING IT TO BE 'RESTART.DAT' AND EDITTING THE TIME TAG (LINE 1) OUT. THIS RESULTS IN LOSS OF ALL DATA SINCE THE LAST SUCCESSFUL RESTART.

THIS SHOULD BE A VERY RARE CASE SINCE EXGO DOES NOT HAVE MORE THAN ONE OF ANY OF ITS FILES OPEN AT ONCE.

**#4. DATA FILE FORMAT.**

**#4.1** RESTART.DAT-THE MAIN RECOVERY DATA FILE. IT IS ACCESSED EACH TIME EXGO IS STARTED FOR THE RUNNING VALUES TO BE USED.

FORMAT: (NOTE, THE ACTUAL FILE HAS COMMA'S AFTER SOME VALUES, THESE ARE FOR EASE IN EDITING AND SHOULD BE RETAINED)

LINE	USE
1	CURRENT VALUE FOR ISAMP
2	CURRENT VALUE FOR NSAMP
3	CURRENT VALUE FOR SUMP1
4	CURRENT VALUE FOR SUMP2
5	CURRENT VALUE FOR JGAUSS
6	CURRENT VALUE FOR DZZZ1
7	CURRENT VALUE FOR XZZZ(1)
8	CURRENT VALUE FOR XZZZ(2)
9	COMMENT LINE(NO DATA IS ON THIS LINE)
10	6 INTERNAL VALUES FOR GAUSS (THE ARRAY NST)
11	7 INTERNAL VALUES FOR BANF (N1 TO N6 AND NP)
12	3 INTERNAL VALUES FOR BANF (T1 TO T3)
13	3 INTERNAL VALUES FOR BANF (T4 TO T6)
14	THE INTEGER VALUE '12345' IS REQUIRED. EXGO USES THIS AS A CHECK TO MAKE SURE THE FILE WAS CORRECTLY WRITTEN.



**#4.2 INITIAL.DAT**-CONTAINS CONSTANT DATA FOR A RUN, BUT THAT MAY VARY BETWEEN RUNS. THIS FILE MAY BE EDITED TO CHANGE RUN CHARACTERISTICS.

**FORMAT:**

LINE	USE
1	I <sub>PRNT</sub> -IF NON-ZERO THEN THE 'CYCLIC INPUT' DATA IS LISTED
2	J <sub>PRNT</sub> -INNER LOOP DATA (IN NDRV3D AND LEAF) IS LISTED WHEN MOD(KOUNT,J <sub>PRNT</sub> ) IS ZERO. SET IT LARGER THAN NO2 IF NO DATA IS DESIRED.
3	K <sub>PRNT</sub> -RUNNING RESULTS ARE PRINTED WHEN MOD(ISAMP,K <sub>PRNT</sub> ) IS ZERO. SET TO PRINT INTERVAL DESIRED.
4	ALP110
5	DELF
6	Q22C
7	Q33C
8	NO2
9	NO3
10	ALF

**#4.3 RUNSTAT.DAT**-A NEW VERSION OF THIS FILE IS CREATED EACH TIME IT IS NEEDED. IT EITHER CONTAINS THE TIME AND DATE OF A SUCCESSFUL RESTART, WITH THE RESTART DATA IN 'RESTART.DAT' FORMAT OR AN ERROR MESSAGE.

**#4.4 RESTART.INT**-THIS FILE CONTAINS THE INITIAL VALUES OF 'RESTART.DAT', SO A NEW RUN WILL INITIALIZE PROPERLY. IT HAS THE SAME FORMAT AS 'RESTART.DAT'.

**#4.5 BACKUP.DAT**-THIS FILE IS A COPY OF 'RESTART.DAT' MADE BEFORE WRITING NEW VALUES TO THE RESART FILE. IT HAS THE SAME FORMAT AS 'RESART.DAT'.

**#5. FORTRAN SOURCE FILES**

**#5.1 NDRV3D.FTN**

THIS FILE CONTAINS THE SAME ROUTINES AS IT ORIGINALLY DID, HOWEVER NDRV3D ITSELF (THE MAIN PROGRAM) HAS BEEN HEAVILY MODIFIED TO INSTALL THE RESTART CAPABILITY. MINOR MODS TO GAUSS AND BANF TO INCLUDE THEIR REMEMBERED VALUES IN COMMON SO THEY CAN BE WRITTEN TO FILES.

**#5.2 LEAF.FTN**

THIS FILE CONTAINS THE SAME ROUTINES AS IT ORIGINNALLY DID, LEAF HAS BEEN SLIGHTLY MODIFIED TO MAKE THE PRINTING OF DATA AT THE END OF EACH CALL OPTIONAL.

**#5.3 KILLME.FTN**

SUBROUTINE KILLME IS CALLED AFTER SETTING UP THE RECOVERY FILES TO SEE IF EVENT FLAG 54 HAS BEEN SET. IT SO IT EXECUTES A STOP.

**#5.4 ERROR.FTN**

SUBROUTINE ERROR IS CALLED WHEN EXGO DISCOVERS ANY ERROR DURING A RESTART ATTEMPT OR WHEN TRYING TO SET UP THE RESTART FILES. ERROR CREATES A VERSION OF 'RUNSTAT.DAT'

CONTAINING AND ERROR MESSAGE AND STOPS.

**#15.5 CTLXGO.FTN**

PROGRAM CTLXGO IS AN INDEPENDENT PROGRAM THAT SETS EVENT FLAG 54 SO THAT EXGO WILL STOP ON ITS NEXT PASS THROUGH THE OUTER LOOP.

**#16. COMMAND FILES**

**#16.1 TEST.CMD**

CONTAINS THE NECESSARY COMMANDS TO TKB EXGO.

**#16.2 NEWRUN.CMD**

CONTAINS THE NECESSARY COMMANDS TO REINIALIZE THE DATA FILES FOR A COMPLETELY NEW RUN OF EXGO.

>

```

.ENABLE DATA
.OPEN BOXBLD.CMD
EXGO/FP/CP,EXGO/CR/-WI=BOXBLD/MP
UNITS=10
ASC=AP:8,AP1:9,AP2:10
PRI=10
//
.CLOSE
.OPEN BOXBLD.ODL
  .ROOT MAIN-*(KILL,ERR,CLOB,REST)
MAIN:  .FCTR NDRV3D-[1,1]FPSLIB/LB:APINIT-[1,1]FPSLIB/LB-[1,1]SHORT
ERR:   .FCTR ERROR
KILL:  .FCTR KILLME
GLOB:  .FCTR [340,340]GLOBAL-[1,1]FPSLIB/LB
REST:  .FCTR REST1-REST2-REST3-REST4-[1,1]FPSLIB/LB
REST1: .FCTR LEAF-[340,340]LC-[1,1]FPSLIB/LB
REST2: .FCTR [340,340]M-[340,340]W-[1,1]FPSLIB/LB
REST3: .FCTR [340,340]ZSUM-[340,340]XSUM-[1,1]FPSLIB/LB
REST4: .FCTR [340,340]TTMOV-[1,1]FPSLIB/LB
      .END
.CLOSE
PIP EXGO.TSK;*/DE
TKB @BOXBLD
PUR EXCO.*,BOXBLD.*

```

>



```

C** NDRV3D.FTN
C   NDRV3D: NEW 3D DRIVER LINEAR LOGGIC
C   VERSION 5/28/78
C   MODIFIED FOR AUTO RESTART 10/4/78 (M.CAMPBELL)
C
0001      REAL JO(1536),JOO(1536),XDAT(130,10),NORM,MNEW,MOLD
0002      INTEGER SN1Z,SINFZ,COSFZ,DELZ,AZ,S1Z,S2Z,T1Z,T2Z
0003      INTEGER H
0004      INTEGER COSF,SINF,CEIL,AGOOLD,AMOLD,AGONEW,AMNEW
0005      INTEGER AAOLD,AANEW,ASC1,ASC2,ASC3,AA2R,AXP1,AADLT
0006      INTEGER ASS
0007      INTEGER AXP2,AGA,ACLF,AAM1,AAM2,AZJ,AXJ,ANORM,ASJ

0008      BYTE MYDATE(9),MYTIME(8)
C THIS COMMON BLOCK CONTAINS PRINT CONTROL VARIABLE
0009      COMMON/PRINTC/IPRNT,JPRNT,KPRNT,KOUNT
0010      COMMON M,N,KMAX,A11,A22,Q33C,PIDLT,ALF,DELT,CONST,R11,
1 MNEW,MOLD,GONEW,GOOLD,PI,TWOPI,Y1EST,Y2EST,Y3EST,
2 CHAT,SHAT,XHAT,NORM,JO,Z1,Z2,
3 COSY(16),SINY(16),AM1
0011      COMMON /GN/ DZZZ1, JGAUSS, XZZZ(2)
C THIS COMMON CONTAINS GAUSS INTERNAL VARIABLE FOR RESTART
0012      COMMON/GSEED/INTRNL(6)
C THIS COMMON CONTAINS BANF INTERNAL VARIABLES FOR RESTART
0013      COMMON/BFINT/IBNF(7),TBNF(6)
0014      COMMON INFLAG,LCHAT,LSHAT,SN1Z,COSFZ,SINFZ,DELZ,JNSZ,JZZ,
1 MEMS,AZ,S1Z,S2Z,INBUFZ,T1Z,T2Z,ITOPS,ALDLT,GA,Q33,COSF,
2 SINF,KBIAS,CEIL,AGOOLD,AMOLD,AGONEW,AMNEW,AAOLD,AANEW,ASC1,
3 ASC2,ASC3,AA2R,AXP1,AADLT,AGA,AXP2,ACLF,AAM1,AAM2,AZJ,AXJ,
4 ANORM,ASJ,ASS

C
C ***** START RUN INITIALIZATION *****
0015      NORM=1.0
C MYFLAG IS THE EVENT FLAG USED TO CONTROL EXGO
0016      MYFLAG=54
0017      CALL CLREF(MYFLAG)
0018      CALL DATE(MYDATE)
0019      CALL TIME(MYTIME)

C
0020      M=16
0021      N=96
0022      KMAX=16
0023      IDEV=5
C BOX MEMORY ALLOCATIONS
0024      INFLAG=17
0025      LCHAT=18
0026      LSHAT=19
0027      SN1Z=20
0028      COSFZ=SN1Z+M
0029      SINFZ=COSFZ+M
0030      DELZ=SINFZ+M
0031      JNSZ=DELZ+N
0032      JZZ=JNSZ+N
0033      MEMS=JZZ+M*N+M
0034      AZ=MEMS+11
0035      S1Z=AZ+11

```

```

0036      S2Z=S1Z+M
0037      INBUFZ=S2Z+M
0038      T1Z=INBUFZ+2
0039      T2Z=T1Z+M
0040      ITOPS=AZ+21+4*M
0041      ALF=1.
      C READ GENERAL PARAMETERS FROM FILE
0042      OPEN(UNIT=1,NAME='INITIAL.DAT',TYPE='OLD',ERR=5000)
0043      READ(1,9999,END=5000)IPRNT,JPRNT,KPRNT,ALP110,DELF,Q22C,Q33C,
      X NO2,NO3,ALF
0044  9999  FORMAT(3(I5,/),4(E15.8,/),2(I5,/),E15.8)
0045      CLOSE(UNIT=1)
0046      IF(IPRNT.NE.0)WRITE(IDEV,651) Y1EST,Y2EST,ALP110,DELF,Q22C,NO2
0047  651  FORMAT(' ',' CYCLIC INPUT'/4X,5F10.5,1I5)
0048      P110=10.**(ALP110/10.)
0049      QQ=Q22C**(.25)
0050      RX=(P110/(SQRT(2.0)*QQ))**(4.0/3.0)
0051      FTC=SQRT(2.0)* RX**(.25) /QQ
0052      DELT=DELF*FTC
0053      Q22=Q22C*DELT
0054      Q33=Q33C*DELT
0055      R11=RX/DELT
0056      P220=P110*SQRT(Q22C/RX)
0057      ALDLT=ALF*DELT
0058      GA=1.-ALDLT
0059      A11=10.***((ALP110+1.4)/10.)
0060      A22= P220
0061      P330=.5*Q33C/ALF
0062      A33=2.0*P330
0063      PI=3.1415926536
0064      PI2=2*PI
0065      TWOPI=2.0*PI
0066      PIDLT=PI/DELT
0067      CONST=-2.0*PIDLT*PIDLT/Q22
0068      DEV1= SQRT(A11)
0069      DEV2= SQRT(A22)
0070      DEV3= SQRT(R11)
0071      DEV4=SQRT(A33)
0072      DEVQ2=SQRT(Q22)
0073      DEVQ3=SQRT(Q33)
0074      Y1EST=0.
0075      Y2EST=0.
0076      Y3EST=1.
0077      IY2=96./2./PIDLT*SQRT(50.*Q22)+.5
0078      KOUNT=1
0079      COSF=20+M
0080      SINF=COSF+M
0081      KBIAS=M*(N+1)
0082      CEIL=ITOPS+KMAX*KBIAS
0083      AGOOLD=CEIL+1
0084      AMOLD=AGOOLD+1
0085      AGONEW=AMOLD+1
0086      AMNEW=AGONEW+1
0087      AAOLD=AMNEW+1
0088      AANEW=AAOLD+KMAX
0089      ASC1=AANEW+KMAX

```

```

0090      ASC2=ASC1+KMAX
0091      ASC3=ASC2+KMAX
0092      AA2R=ASC3+KMAX
0093      AXP1=AA2R+KMAX
0094      AADLT=AXP1+1
0095      AGA=AADLT+1
0096      AXP2=AGA+1
0097      ACLF=AXP2+1
0098      AAM1=ACLF+KMAX*KMAX
0099      AAM2=AAM1+1
0100      AZJ=AAM2+1
0101      AXJ=AZJ+KMAX
0102      ANORM=AXJ+M
0103      ASJ=ANORM+1
0104      ASS=ASJ+KMAX

C-----READ RESTART FILE
C NOTE-FIRST RUN IS CONTROLLED BY RESTART FILE VAUES ALSO
C
0105      OPEN(UNIT=1,NAME='RESTART.DAT',TYPE='OLD',ERR=5010)
0106      READ(1,9998,END=5015)ISAMP,NSAMP,SUMP1,SUMP2,JGAUSS,DZZZ1
      X ,XZZZ,INTRNL,IBNF,TBNF,MYRSTR
C THIS FORMAT ALSO USED BY RECOVERY SETUP CODE AT END OF OUTER LOOP
0107      9998      FORMAT(2(I15,/),2(E15.8,/),I15,/,3(E15.8,/),/,6I10,/
      X ,7I10,/,2(3F15.5,/),I15)
0108      CLOSE(UNIT=1)
0109      IF(MYRSTR.NE.12345)GO TO 5020
C RESTART SUCCESSFULL
0110      GO TO 6000
C UNSUCCESSFUL RESTART BRANCHES
C
C UNABLE TO OPEN OR ACCESS CONSTANT FILE
C
0111      5000      CONTINUE
0112      CALL ERROR(1,1)
C UNABLE TO OPEN PRIMARY RESTART FILE
0113      5010      CONTINUE
0114      CALL ERROR(1,2)
C END-OF-FILE ON PRIMARY RESTART FILE
0115      5015      CONTINUE
0116      CALL ERROR(1,3)
C CONSISTENCY VARIABE -MYRSTR- DOES NOT HAVE VALUE OF '12345'
0117      5020      CONTINUE
0118      CALL ERROR(1,4)
C
C SUCCESSFUL RESTART
C
0119      6000      CONTINUE
0120      OPEN(UNIT=1,NAME='RUNSTAT.DAT',TYPE='NEW')
0121      WRITE(1,9991)MYTIME,MYDATE
0122      9991      FORMAT(1X,8A1,1X,9A1,' RESTART SUCCESSFUL')
0123      WRITE(1,9990)ISAMP,NSAMP,SUMP1,SUMP2,JGAUSS,DZZZ1,
      X XZZZ,INTRNL,IBNF,TBNF
0124      CLOSE(UNIT=1)
C THIS FORMAT ALSO USED BY RECOVER SET UP CODE AT END OF OUTER LOOP
0125      9990      FORMAT(I15,' ,ISAMP',/
      X I15,' ,NSAMP',/

```



```

      X E15.8, ,SUMP1, /
      X E15.8, ,SUMP2, /
      X I15, ,JGAUSS, /
      X E15.8, ,DZZZ1, /
      X E15.8, ,XZZZ(1), /
      X E15.8, ,XZZZ(2), /
      X  THE FOLLOWING ARE INTERNAL TO GAUSS AND BANF, /
      X ,6I10, /,
      X 7I10, /
      X ,3E15.8, /
      X ,3E15.8, /
      X 12345 , FILE CONSISTENCY CHECK VALUE)

C
C***** END RUN CONSTANTS *****
C
0126      CALL GLOBAL
C
C***** START PATH INITIALIZATION *****
C
0127      100  CONTINUE
0128          CALL GAUSS(JSEED,DEV1,Y1EST,X1)
0129          KOUNT=1
0130          XDAT(KOUNT,1)=X1
0131          CALL GAUSS(JSEED,DEV2,Y2EST,X2)
0132          CALL GAUSS(JSEED,DEV4,Y3EST,X3)
0133          XDAT(KOUNT,5)=X3
0134          ACOS=EXP(X3-1.)*COS(X1)
0135          ASIN=EXP(X3-1.)*SIN(X1)
0136          DO 11 K=1,KMAX
0137              YY3=.5*(FLOAT(KMAX)+1.)
0138              G=.5*(FLOAT(K)-YY3)
0139              G=G*.5
0140              AMFAK=0.
0141              IF (G.GT.27.) GO TO 12
0142              AMFAK=EXP(-G )
0143      12  CONTINUE
0144          MN=M*N
0145          DO 10 I= 1,M
0146              DO 10 J=1,N
0147                  L1=I+M*(J-1)
0148                  L2=M*(N+1)*(K-1)+ITOPS
0149      10  J00(L1)=J0(L1)*AMFAK
0150          L4=776
0151          CALL APPUT(J00,L2,MN,2)
0152          CALL APWD
0153      11  CONTINUE
0154          GOOLD=1.0+(-.5-FLOAT(KMAX)/2.)*.5*SQRT(A33)
0155          MOLD=SQRT(A33)/2.
0156          GONEW=GOOLD
0157          MNEW=MOLD
0158          CALL APPUT(GOOLD,AGOOLD,1,2)
0159          CALL APPUT(MOLD,AMOLD,1,2)
0160          CALL APPUT(GONEW,AGONEW,1,2)
0161          CALL APPUT(MNEW,AMNEW,1,2)
0162          CALL APWD
0163      205  FORMAT('0',8X,'POSIT.',5X,'POSIT. MOD 2 PI',2X,'EST. POSIT.',9X

```

\*/Z1 AND Z2, 19X, CYCLIC LOSS, 5X, K-B EST. AND P11)

C  
C \*\*\*\*\* END PATH INITIALIZATION \*\*\*\*\*  
C  
C \*\*\*\*\* START POINTS \*\*\*\*\*  
C

```

0164      450 CONTINUE
0165          IF (KOUNT.LE.1) GO TO 5
0166          ACOS=EXP(X3-1.)*COS(X1)
0167          ASIN=EXP(X3-1.)*SIN(X1)
0168      5    CALL GAUSS(JSEED,DEV3,ACOS,Z1)
0169          CALL GAUSS(JSEED,DEV3,ASIN,Z2)
0170          X1=X1 + X2*DELT
0171          XDAT(KOUNT,1)=X1
0172          CALL GAUSS(JSEED,DEVQ2,X2,X2)
0173          X3=GA*X3+ALDLT
0174          CALL GAUSS(JSEED,DEVQ3,X3,X3)
0175          XDAT(KOUNT,5)=X3
0176          CALL LEAF
0177          XDAT(KOUNT,2)=XHAT
0178          XDAT(KOUNT,4)=AM1

0179          IF(MOD(KOUNT,JPRNT).EQ.0)WRITE(IDEV,201)KOUNT,XDAT(KOUNT,1),
X XDAT(KOUNT,2),Z1,Z2,
*(XDAT(KOUNT,5)),AM1
0180      201  FORMAT('0',I3,1X,1P2E14.6/4X,1P2E14.6,4X,1P2E14.6 /)
0181          KOUNT=KOUNT + 1
0182          IF (KOUNT.LE.NO2) GO TO 450

```

C  
C \*\*\*\*\* END POINTS \*\*\*\*\*  
C  
C \*\*\*\*\* START FINISH PATH \*\*\*\*\*  
C

```

0183          SUMP=0.0
0184          SUMC=0.0
0185          DO 1501 I=31,NO2
0186              XD=ABS(XDAT(I,1)-XDAT(I,2))
0187      1498  CONTINUE
0188              IF(XD.GT.PI) GO TO 1499
0189              GO TO 1500
0190      1499  XD=XD-PI2
0191              GO TO 1498
0192      1500  SUMP=(XD)**2+SUMP
0193              SUMC=SUMC+(XDAT(I,5)-XDAT(I,4))**2
0194      1501  CONTINUE

0195          H=NO2-30
0196          SUMP=SUMP/H
0197          SUMC=SUMC/H
0198          XNSAMP=NSAMP
0199          XAA=XNSAMP+1.0
0200          SUMP1=(SUMP+XNSAMP*SUMP1)/XAA
0201          SUMP2=(SUMC+XNSAMP*SUMP2)/XAA
0202          DSUMP1=ALOG10(SUMP1)*10.
0203          DSUMP2=ALOG10(SUMP2)*10.
0204          IF(MOD(NSAMP,KPRNT).EQ.0)WRITE(IDEV,1508)

```

```

0205      1508 FORMAT('0',5X,'NONLINEAR CYCLIC ESTIMATOR')
0206          IF(MOD(NSAMP,KPRNT).EQ.0)WRITE(IDEV,1511)SUMP1,DSUMP1,SUMP2,
          *DSUMP2
0207      1511 FORMAT(2('0','AVERAGE STATISTICAL VARIANCE =',1PE13.6, /1X,
          * 'AVERAGE COMPUTED VARIANCE =',1PE13.6//))
0208          NSAMP=NSAMP+1
0209          ISAMP=ISAMP+1
          C
          C BUILD RESTART FILES
          C
          C FIRST COPY THE CURRENT PRIMARY FILE TO THE BACKUP
          C
0210          OPEN(UNIT=1,NAME='RESTART.DAT',TYPE='OLD',ERR=7000)
0211          READ(1,9998,ERR=7010)I1,I2,R1,R2,I3,R3,R4,R5,
          X I4,I5,I6,I7,I8,I9,
          X I10,I11,I12,I13,I14,I15,I16,
          X R7,R8,R9,R10,R11,R12,
          X MYRSTR
0212          CLOSE(UNIT=1)
0213          IF(MYRSTR.NE.12345)GO TO 7020
          C WRITE BACKUP FILE
0214          OPEN(UNIT=1,NAME='BACKUP.DAT',TYPE='UNKNOWN',ERR=7030)
0215          WRITE(1,9990)I1,I2,R1,R2,I3,R3,R4,R5,
          X I4,I5,I6,I7,I8,I9,
          X I10,I11,I12,I13,I14,I15,I16,
          X R7,R8,R9,R10,R11,R12
0216          CLOSE(UNIT=1)
          C WRITE CURRENT DATA ON NEW PRIMARY FILE
0217          OPEN(UNIT=1,NAME='RESTART.DAT',TYPE='UNKNOWN',ERR=7040)
0218          WRITE(1,9990)ISAMP,NSAMP,SUMP1,SUMP2,JGAUSS,DZZZ1,
          X XZZZ,INTRNL,IBNF,TBNF
          C
0219          CLOSE(UNIT=1)
          C IF WE GET HERE WE SUCCESSFULLY SET UP RESTART-SKIP AROUND ERRORS
0220          GO TO 7050
          C
          C RESTART SETUP ERRORS
          C
          C UNABLE TO OPEN CURRENT RESTART FILE TO BUILD BACKUP
          C
0221      7000      CONTINUE
0222          CALL ERROR(2,1)
          C END OF FILE ON RESTART FILE
0223      7010      CONTINUE
0224          CALL ERROR(2,2)
          C RESTART FILE CONSISTENCY VALUE BAD
0225      7020      CONTINUE
0226          CALL ERROR(2,3)
          C OPEN FAILURE ON BACKUP FILE
0227      7030      CONTINUE
0228          CALL ERROR(2,4)
          C OPEN FAILURE ON SECOND OPEN OF RESTART FILE
0229      7040      CONTINUE
0230          CALL ERROR(2,5)
0231      7050      CONTINUE
          C

```



```
      C SEE IF WE QUIT DUE TO EVENT FLAG
      C
0232      CALL KILLME(MYFLAG)
0233      IF (ISAMP.LE.NO3) GO TO 100
      C
      C ***** END FINISH PATH *****
      C
      C ***** FINISH RUN *****
      C
0234      2200 WRITE(IDEV,2201)
0235      2201 FORMAT ('O',10X,'NORMAL COMPLETION')
0236      STOP
0237      END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE	ATTRIBUTES
1	\$CODE1	006546 1715	RW,I,CON,LCL
2	\$PDATA	000114 38	RW,D,CON,LCL
3	\$IDATA	001546 435	RW,D,CON,LCL
4	\$VARS	026530 5804	RW,D,CON,LCL
5	\$TEMPS	000010 4	RW,D,CON,LCL
6	PRINTC	000010 4	RW,D,OVR,GBL
7	.\$\$\$\$.	014510 3236	RW,D,OVR,GBL
8	GN	000016 7	RW,D,OVR,GBL
9	GSEED	000014 6	RW,D,OVR,GBL
10	BFINT	000046 19	RW,D,OVR,GBL

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AADLT	I*2	7-014462	AAM1	I*2	7-014472	AAM2	I*2	7-014474
AANEW	I*2	7-014446	AAOLD	I*2	7-014444	AA2R	I*2	7-014456
ACLF	I*2	7-014470	ACOS	R*4	4-026322	AGA	I*2	7-014464
AGONEW	I*2	7-014440	AGOOLD	I*2	7-014434	ALDLT	R*4	7-014410
ALF	R*4	7-000026	ALP110	R*4	4-026150	AMFAK	R*4	4-026344
AMNEW	I*2	7-014442	AMOLD	I*2	7-014436	AM1	R*4	7-014342
ANORM	I*2	7-014502	ASCL	I*2	7-014450	ASC2	I*2	7-014452
ASC3	I*2	7-014454	ASIN	R*4	4-026326	ASJ	I*2	7-014504
ASS	I*2	7-014506	AXJ	I*2	7-014500	AXP1	I*2	7-014460
AXP2	I*2	7-014466	AZ	I*2	7-014372	AZJ	I*2	7-014476
A11	R*4	7-000006	A22	R*4	7-000012	A33	R*4	4-026224
CEIL	I*2	7-014432	CHAT	R*4	7-000112	CONST	R*4	7-000036
COSF	I*2	7-014424	COSFZ	I*2	7-014356	DELF	R*4	4-026154
DELT	R*4	7-000032	DELZ	I*2	7-014362	DEVQ2	R*4	4-026254
DEVQ3	R*4	4-026260	DEV1	R*4	4-026234	DEV2	R*4	4-026240
DEV3	R*4	4-026244	DEV4	R*4	4-026250	DSUMP1	R*4	4-026410
DSUMP2	R*4	4-026414	DZZZ1	R*4	8-000000	FTC	R*4	4-026204
G	R*4	4-026340	GA	R*4	7-014414	GONEW	R*4	7-000056
GOOLD	R*4	7-000062	H	I*2	4-026120	I	I*2	4-026352
IDEV	I*2	4-026146	INBUF2	I*2	7-014400	INFLAG	I*2	7-014346
IPRNT	I*2	6-000000	ISAMP	I*2	4-026266	ITOPS	I*2	7-014406
IY2	I*2	4-026264	I1	I*2	4-026420	I10	I*2	4-026466
I11	I*2	4-026470	I12	I*2	4-026472	I13	I*2	4-026474
I14	I*2	4-026476	I15	I*2	4-026500	I16	I*2	4-026502
I2	I*2	4-026422	I3	I*2	4-026434	I4	I*2	4-026452
I5	I*2	4-026454	I6	I*2	4-026456	I7	I*2	4-026460
I8	I*2	4-026462	I9	I*2	4-026464	J	I*2	4-026354
JGAUSS	I*2	8-000004	JNSZ	I*2	7-014364	JPRNT	I*2	6-000002
JSEED	I*2	4-026304	JZZ	I*2	7-014366	K	I*2	4-026332
KBIAS	I*2	7-014430	KMAX	I*2	7-000004	KOUNT	I*2	6-000006
KPRNT	I*2	6-000004	LCHAT	I*2	7-014350	LSHAT	I*2	7-014352
L1	I*2	4-026356	L2	I*2	4-026360	L4	I*2	4-026362
M	I*2	7-000000	MEMS	I*2	7-014370	MN	I*2	4-026350
MNEW	R*4	7-000046	MOLD	R*4	7-000052	MYFLAG	I*2	4-026144
MYRSTR	I*2	4-026302	N	I*2	7-000002	NORM	R*4	7-000126
NO2	I*2	4-026164	NO3	I*2	4-026166	NSAMP	I*2	4-026270

PI	R*4	7-000066	PIDLT	R*4	7-000022	PI2	R*4	4-026230
P110	R*4	4-026170	P220	R*4	4-026214	P330	R*4	4-026220
QQ	R*4	4-026174	Q22	R*4	4-026210	Q22C	R*4	4-026160
Q33	R*4	7-014420	Q33C	R*4	7-000016	RX	R*4	4-026200
R1	R*4	4-026424	R10	R*4	4-026520	R11	R*4	7-000042
R12	R*4	4-026524	R2	R*4	4-026430	R3	R*4	4-026436
R4	R*4	4-026442	R5	R*4	4-026446	R7	R*4	4-026504
R8	R*4	4-026510	R9	R*4	4-026514	SHAT	R*4	7-000116
SINF	I*2	7-014426	SINFZ	I*2	7-014360	SN12	I*2	7-014354
SUMC	R*4	4-026370	SUMP	R*4	4-026364	SUMP1	R*4	4-026272
SUMP2	R*4	4-026276	S1Z	I*2	7-014374	S2Z	I*2	7-014376
TWOPI	R*4	7-000072	T1Z	I*2	7-014402	T2Z	I*2	7-014404
XAA	R*4	4-026404	XD	R*4	4-026374	XHAT	R*4	7-000122
XNSAMP	R*4	4-026400	X1	R*4	4-026306	X2	R*4	4-026312
X3	R*4	4-026316	YY3	R*4	4-026334	Y1EST	R*4	7-000076
Y2EST	R*4	7-000102	Y3EST	R*4	7-000106	Z1	R*4	7-014132
Z2	R*4	7-014136						

# ARRAYS

NAME	TYPE	ADDRESS	SIZE	DIMENSIONS
COSY	R*4	7-014142	000100	32 (16)
IBNF	I*2	10-000000	000016	7 (7)
INTRNL	I*2	9-000000	000014	6 (6)
JO	R*4	7-000132	014000	3072 (1536)
JOO	R*4	4-000000	014000	3072 (1536)
MYDATE	L*1	4-026122	000011	4 (9)
MYTIME	L*1	4-026133	000010	4 (8)
SINY	R*4	7-014242	000100	32 (16)
TBNF	R*4	10-000016	000030	12 (6)
XDAT	R*4	4-014000	012120	2600 (130,10)
XZZZ	R*4	8-000006	000010	4 (2)

# LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
5	1-004026	10	**	11	**
12	1-003326	100	1-003014	201	3-000542
205	**	450	1-003726	651	3-000032
1498	1-004476	1499	1-004524	1500	1-004552
1501	**	1508	3-000600	1511	3-000642
2200	**	2201	3-000764	5000	1-002466
5010	1-002504	5015	1-002522	5020	1-002540
6000	1-002556	7000	1-006360	7010	1-006376
7020	1-006414	7030	1-006432	7040	1-006450
7050	1-006466	9990	3-000204	9991	3-000146
9998	3-000066	9999	3-000000		

# FUNCTIONS AND SUBROUTINES REFERENCED

APPUT	APWD	CLOS\$	CLREF	DATE	ERROR	GAUSS	GLOBAL	KILLME	LEAF
-------	------	--------	-------	------	-------	-------	--------	--------	------



FORTTRAN IV-PLUS V02-51D  
NDRV3D.FTN /TR:BLOCKS/WR

11:10:03

05-APR-79

PAGE 10

OPEN\$	TIME	\$ALG10	\$COS	\$EXP	\$SIN	\$SQRT
--------	------	---------	-------	-------	-------	--------

TOTAL SPACE ALLOCATED - 054010 11268

```
0001      SUBROUTINE GAUSS(JS,SD,XM,X)
0002      COMMON/GSEED/ NST(6)
0003      COMMON /GN/ TWOPI, J, XR(2)
0004      IF (J) 10, 10, 20
0005      10 J=2
0006          TWOPI=8.*(ATAN(1.))
0007          NST(1)=25
0008          NST(2)=8
0009          NST(3)=31
0010          NST(4)=45
0011          NST(5)=20
0012          NST(6)=17
0013          XR(1)=BANF(NST,1)
0014          GO TO 35
0015      20 GO TO (30,40), J
0016      30 J=2
0017          XR(1)=BANF(NST,0)
0018      35 XR(2)=BANF(NST,0)
0019          X1=SQRT(ABS(-2.*ALOG(XR(1))))
0020          XR(2)=TWOPI*XR(2)
0021          XR(1)=X1*SIN(XR(2))
0022          XR(2)=X1*COS(XR(2))
0023          X=XR(1)*SD+XM
0024          RETURN
0025      40 J=1
0026          X=XR(2)*SD+XM
0027          RETURN
0028          END
```

PROGRAM SECTIONS

NUMBER	NAME	SIZE	ATTRIBUTES
1	\$CODE1	000454 150	RW,I,CON,LCL
2	\$PDATA	000016 7	RW,D,CON,LCL
3	\$IDATA	000014 6	RW,D,CON,LCL
4	\$VARS	000004 2	RW,D,CON,LCL
6	GSEED	000014 6	RW,D,OVR,GBL
7	GN	000016 7	RW,D,OVR,GBL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
GAUSS		1-000000						

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
J	I*2	7-000004	JS	I*2	F-000002*	SD	R*4	F-000004*
TWOPI	R*4	7-000000	X	R*4	F-000010*	XM	R*4	F-000006*
X1	R*4	4-000000						

ARRAYS

NAME	TYPE	ADDRESS	SIZE	DIMENSIONS
NST	I*2	6-000000	000014 6	(6)
XR	R*4	7-000006	000010 4	(2)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
10	**	20	1-000152	30	1-000174
35	1-000234	40	1-000414		

FUNCTIONS AND SUBROUTINES REFERENCED

BANF \$ALOG \$ATAN \$COS \$SIN \$SQRT

TOTAL SPACE ALLOCATED = 000544 178



```

0001      FUNCTION BANF(NS,MODE)
0002      DIMENSION NS(6), NC(6)
          C COMMON FOR HOLDING RESTART VALUES
0003      COMMON/BFINT/IBNF(7),TBNF(6)
0004      EQUIVALENCE(N1,IBNF(1)),(N2,IBNF(2)),(N3,IBNF(3))
0005      EQUIVALENCE(N4,IBNF(4)),(N5,IBNF(5)),(N6,IBNF(6))
0006      EQUIVALENCE(MP,IBNF(7))
0007      EQUIVALENCE(T1,TBNF(1)),(T2,TBNF(2)),(T3,TBNF(3))
0008      EQUIVALENCE(T4,TBNF(4)),(T5,TBNF(5)),(T6,TBNF(6))
0009      DATA M1,M2,M3,M4,M5,M6/59,47,62,38,45,23/
          C      MODE=0 TO CONTINUE, OTHERWISE RESTART WITH
          C      INTEGER NUMBER NS(1)*2**18+NS(2)
0010      IF (MODE) 10, 100, 10
0011      10 N1=NS(1)
0012      N2=NS(2)
0013      N3=NS(3)
0014      N4=NS(4)
0015      N5=NS(5)
0016      N6=NS(6)
0017      T1=2.**(-6)
0018      T2=2.**(-12)
0019      T3=2.**(-18)
0020      T4=2.**(-24)
0021      T5=2.**(-30)
0022      T6=2.**(-36)
0023      MP=2**6
0024      100 DO 200 I=1,6
0025      GO TO (110,120,130,140,150,160),I
0026      110 K=N6*M6
0027      GO TO 190
0028      120 K=N6*M5+N5*M6+KD
0029      GO TO 190
0030      130 K=N6*M4+N5*M5+N4*M6+KD
0031      GO TO 190
0032      140 K=N6*M3+N5*M4+N4*M5+N3*M6+KD
0033      GO TO 190
0034      150 K=N6*M2+N5*M3+N4*M4+N3*M5+N2*M6+KD
0035      GO TO 190
0036      160 K=N6*M1+N5*M2+N4*M3+N3*M4+N2*M5+N1*M6+KD
0037      190 KD=K/MP
0038      200 NC(I)=K-KD*MP
0039      N1=NC(6)
0040      N2=NC(5)
0041      N3=NC(4)
0042      N4=NC(3)
0043      N5=NC(2)
0044      N6=NC(1)
0045      XN1=N1
0046      XN2=N2
0047      XN3=N3
0048      XN4=N4
0049      XN5=N5
0050      XN6=N6
0051      BANF=XN1*T1+XN2*T2+XN3*T3+XN4*T4+XN5*T5+XN6*T6
0052      RETURN

```

FORTAN IV-PLUS V02-51D  
NDRV3D.FTN /TR:BLOCKS/WR

11:10:47 05-APR-79

PAGE 14

0053

END

PROGRAM SECTIONS

NUMBER	NAME	SIZE	ATTRIBUTES
1	\$CODE1	001344 370	RW,I,CON,LCL
2	\$PDATA	000016 7	RW,D,CON,LCL
3	\$IDATA	000016 7	RW,D,CON,LCL
4	\$VARS	000066 27	RW,D,CON,LCL
6	BFINT	000046 19	RW,D,OVR,GBL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
BANF	R*4	1-000000						

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
I	I*2	4-000030	K	I*2	4-000032	KD	I*2	4-000034
MODE	I*2	F-000004*	MP	I*2	6-000014	M1	I*2	4-000014
M2	I*2	4-000016	M3	I*2	4-000020	M4	I*2	4-000022
M5	I*2	4-000024	M6	I*2	4-000026	N1	I*2	6-000000
N2	I*2	6-000002	N3	I*2	6-000004	N4	I*2	6-000006
N5	I*2	6-000010	N6	I*2	6-000012	T1	R*4	6-000016
T2	R*4	6-000022	T3	R*4	6-000026	T4	R*4	6-000032
T5	R*4	6-000036	T6	R*4	6-000042	XN1	R*4	4-000036
XN2	R*4	4-000042	XN3	R*4	4-000046	XN4	R*4	4-000052
XN5	R*4	4-000056	XN6	R*4	4-000062			

ARRAYS

NAME	TYPE	ADDRESS	SIZE	DIMENSIONS
IBNF	I*2	6-000000	000016	7 (7)
NC	I*2	4-000000	000014	6 (6)
NS	I*2	F-000002*	000014	6 (6)
TBNF	R*4	6-000016	000030	12 (6)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
10	**	100	1-000334	110	1-000372
120	1-000420	130	1-000462	140	1-000536
150	1-000624	160	1-000724	190	1-001034
200	**				

TOTAL SPACE ALLOCATED = 001534 430



```

0001      SUBROUTINE GLOBAL
          C      VERSION 5/5/1978
0002      REAL A(20),ABOX(20),JO(1536),SIGMA(16),NORM,MOLD,MNEW,
          1 S1(16),S2(16),PSI(96),DELJ(96)
0003      INTEGER SN1Z,COSFZ,SINFZ,DELZ,AZ,S1Z,S2Z,T1Z,T2Z,JNS(96)
0004      INTEGER COSF,SINF,CEIL,AGOOLD,AMOLD,AGONEW,AMNEW
0005      INTEGER AAOLD,AANEW,ASC1,ASC2,ASC3,AA2R,AXP1,AADLT
0006      INTEGER ASS
0007      INTEGER AXP2,AGA,ACLF,AAM1,AAM2,AZJ,AXJ,ANORM,ASJ

0008      COMMON M,N,KMAX,A11,A22,Q33C,PIDLT,ALF,DELT,CONST,R11,
          1 MNEW,MOLD,GONEW,GOOLD,PI,TWOPI,Y1EST,Y2EST,Y3EST,
          2 CHAT,SHAT,XHAT,NORM,JO,Z1,Z2,
          3 COSY(16),SINY(16),AMI
0009      COMMON INFLAG,LCHAT,LSHAT,SN1Z,COSFZ,SINFZ,DELZ,JNSZ,JZZ,
          1 MEMS,AZ,S1Z,S2Z,INBUFZ,T1Z,T2Z,ITOPS,ALDLT,GA,Q33,COSF,
          2 SINF,KBIAS,CEIL,AGOOLD,AMOLD,AGONEW,AMNEW,AAOLD,AANEW,ASC1,
          3 ASC2,ASC3,AA2R,AXP1,AADLT,AGA,AXP2,ACLF,AAM1,AAM2,AZJ,AXJ,
          4 ANORM,ASJ,ASS
          C      GLOBAL INITIALIZATIONS FOR NONLINEAR FILTER
0010      200 CALL APINIT(1,1,III)
          C      CLEAR MD(0)-MD(8191)
0011      DO 202 I=1,1024
0012      202 JO(I)=0.0
0013      ISTART=0
0014      DO 204 I=1,64
0015      CALL APPUT(JO,ISTART,1024,2)
0016      ISTART=ISTART+1024
0017      204 CONTINUE
0018      A5=-1./R11/2.
0019      CALL APPUT(A5,AXP1,1,2)
0020      CALL APWD
0021      X5=DELT*ALF
0022      X5=-X5
0023      CALL APPUT(X5,AADLT,1,2)
0024      CALL APWD
0025      A5=-GA
0026      CALL APPUT(A5,AGA,1,2)
0027      CALL APWD
0028      A5=-1./2./Q33C/DELT
0029      CALL APPUT(A5,AXP2,1,2)
0030      CALL APWD
0031      A5=1.
0032      CALL APPUT(A5,ANORM,1,2)
0033      CALL APWD
          C
0034      NORM=1.0
          C
          C      PHASE VARIABLES
0035      DO 210 I=1,M
0036      SIGMA(I)=PI*((2.*I-1.)/FLOAT(M)-1.)
0037      COSY(I)=COS(SIGMA(I))
0038      SINY(I)=SIN(SIGMA(I))
0039      S1(I)=COSY(I)/R11
0040      210 S2(I)=SINY(I)/R11
0041      CALL APPUT(COSY,COSFZ,M,2)

```

AD-A073 051

UNIVERSITY OF SOUTHERN CALIFORNIA LOS ANGELES DEPT O--ETC F/G 9/2  
SOFTWARE FOR NONLINEAR FILTERING.(U)

JUN 79 R S BUCY, F GHovanlou

F44620-76-C-0085

UNCLASSIFIED

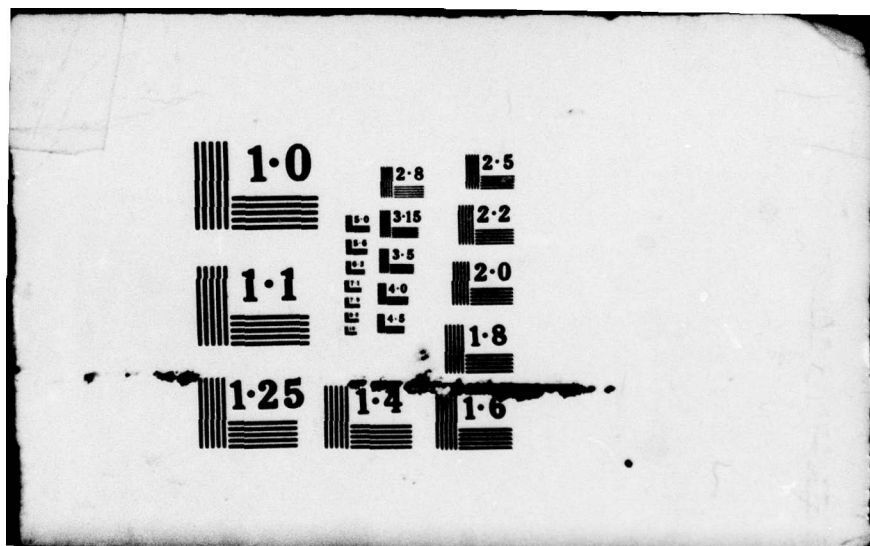
USCAE-53-4514-1787

AFOSR-TR-79-0923

NL

2 OF 2  
AD  
A07305







```

0042      CALL APPUT(SINY,SINFZ,M,2)
0043      CALL APPUT(S1,S1Z,M,2)
0044      CALL APPUT(S2,S2Z,M,2)
0045      CALL APWD
      C
      C      PHASE RATE VARIABLES
0046      DO 220 I=1,N
0047      220   PSI(I)=PIDLT*((2.*I-1.)/FLOAT(N)-1.)
      C
      C      INTERPOLATION ADDRESS AND FACTORS
0048      AM=M
0049      AN=N
0050      DO 230 J=1,N
0051      AJ=J
0052      PRQ=(AM/AN+AM)/2.-AM/AN*AJ+AM
0053      IRQ=PRQ
0054      DELJ(J)=PRQ-IRQ
0055      230   JNS(J)=MOD(IRQ,M)+1
0056      CALL APPUT(DELJ,DELZ,N,2)
0057      CALL APPUT(JNS,JNSZ,N,1)
0058      CALL APWD
      C
      C      EVALUATE CONVOLUTION TERMS A(I)
0059      DO 280 I=1,NTERM
0060      TEMP=I/FLOAT(N)
0061      TEMP=CONST*TEMP*TEMP
      C
      C      A(I)=0.
0062      280   IF (TEMP.GT.-20) A(I)=EXP(TEMP)
0063      280   A(I)=EXP(TEMP)
0064      DO 282 I=1,5
0065      282   ABOX(I)=A(6-I)
0066      ABOX(6)=1.
0067      DO 284 I=1,5
0068      284   ABOX(I+6)=A(I)
0069      ABOX(1)=0.0
0070      ABOX(11)=0.0
0071      CALL APPUT(ABOX,AZ,11,2)
0072      CALL APWD
      C      DUMPED ABOX HERE
      C      CONSTRUCT THE A PRIORI DENSITY
      C      CNORM=1.0/(TWOPI*SQRT(A11*A22))
0073      CNORM=1.
0074      CL=-0.5/A22
0075      SI=-0.5/A11
0076      DO 290 I=1,M
0077      CR=SIGMA(I)-Y1EST
0078      CR=CR*CR*SI
0079      J1=0
0080      DO 290 J=1,N
0081      J2=J1+I
0082      TEMP=PSI(J)-Y2EST
0083      JO(J2)=0.
0084      TEMP1=TEMP*TEMP*CL+CR
0085      IF (TEMP1.LE.-27) GOTO 290
0086      290   JO(J2)=EXP(TEMP1)*CNORM
      J1=J1+M

```

FORTAN IV-PLUS V02-51D  
GLOBAL.FTN /TR: BLOCKS/WR

12:25:14

05-APR-79

PAGE 3

0087  
0088

RETURN  
END

PROGRAM SECTIONS

NUMBER	NAME	SIZE	ATTRIBUTES
1	\$CODE1	002120 552	RW,I,CON,LCL
2	\$PDATA	000020 8	RW,D,CON,LCL
3	\$IDATA	000214 70	RW,D,CON,LCL
4	\$VARS	002540 688	RW,D,CON,LCL
5	\$TEMPS	000014 6	RW,D,CON,LCL
6	.\$\$\$\$.	014510 3236	RW,D,OVR,GBL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
GLOBAL		1-000000						

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AADLT	I*2	6-014462	AAM1	I*2	6-014472	AAM2	I*2	6-014474
AANEW	I*2	6-014446	AAOLD	I*2	6-014444	AA2R	I*2	6-014456
ACLF	I*2	6-014470	AGA	I*2	6-014464	AGONEW	I*2	6-014440
AGOOLD	I*2	6-014434	AJ	R*4	4-002470	ALDLT	R*4	6-014410
ALF	R*4	6-000026	AM	R*4	4-002456	AMNEW	I*2	6-014442
AMOLD	I*2	6-014436	AM1	R*4	6-014342	AN	R*4	4-002462
ANORM	I*2	6-014502	ASC1	I*2	6-014450	ASC2	I*2	6-014452
ASC3	I*2	6-014454	ASJ	I*2	6-014504	ASS	I*2	6-014506
AXJ	I*2	6-014500	AXP1	I*2	6-014460	AXP2	I*2	6-014466
AZ	I*2	6-014372	AZJ	I*2	6-014476	Al1	R*4	6-000006
A22	R*4	6-000012	A5	R*4	4-002446	CEIL	I*2	6-014432
CHAT	R*4	6-000112	CL	R*4	4-002514	CNORM	R*4	4-002510
CONST	R*4	6-000036	COSF	I*2	6-014424	COSFZ	I*2	6-014356
CR	R*4	4-002524	DELT	R*4	6-000032	DELZ	I*2	6-014362
GA	R*4	6-014414	GONEW	R*4	6-000056	GOOLD	R*4	6-000062
I	I*2	4-002442	III	I*2	4-002440	INBUFZ	I*2	6-014400
INFLAG	I*2	6-014346	IRQ	I*2	4-002500	ISTART	I*2	4-002444
ITOPS	I*2	6-014406	J	I*2	4-002466	JNSZ	I*2	6-014364
JZZ	I*2	6-014366	J1	I*2	4-002530	J2	I*2	4-002532
KBIAS	I*2	6-014430	KMAX	I*2	6-000004	LCHAT	I*2	6-014350
LSHAT	I*2	6-014352	M	I*2	6-000000	MEMS	I*2	6-014370
MNEW	R*4	6-000046	MOLD	R*4	6-000052	N	I*2	6-000002
NORM	R*4	6-000126	NTERM	I*2	4-002502	PI	R*4	6-000066
PIDLT	R*4	6-000022	PRQ	R*4	4-002474	Q33	R*4	6-014420
Q33C	R*4	6-000016	R11	R*4	6-000042	SHAT	R*4	6-000116
SI	R*4	4-002520	SINF	I*2	6-014426	SINFZ	I*2	6-014360
SN1Z	I*2	6-014354	S1Z	I*2	6-014374	S2Z	I*2	6-014376
TEMP	R*4	4-002504	TEMP1	R*4	4-002534	TWOPI	R*4	6-000072
T1Z	I*2	6-014402	T2Z	I*2	6-014404	XHAT	R*4	6-000122
X5	R*4	4-002452	Y1EST	R*4	6-000076	Y2EST	R*4	6-000102
Y3EST	R*4	6-000106	Z1	R*4	6-014132	Z2	R*4	6-014136



ARRAYS

NAME	TYPE	ADDRESS	SIZE	DIMENSIONS
A	R*4	4-000000	000120	40 (20)
ABOX	R*4	4-000120	000120	40 (20)
COSY	R*4	6-014142	000100	32 (16)
DELJ	R*4	4-001340	000600	192 (96)
JNS	I*2	4-002140	000300	96 (96)
JO	R*4	6-000132	014000	3072 (1536)
PSI	R*4	4-000540	000600	192 (96)
SIGMA	R*4	4-000240	000100	32 (16)
SINY	R*4	6-014242	000100	32 (16)
S1	R*4	4-000340	000100	32 (16)
S2	R*4	4-000440	000100	32 (16)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
200	**	202	**	204	**
210	**	220	**	230	**
280	**	282	**	284	**
290	1-002052				

FUNCTIONS AND SUBROUTINES REFERENCED

APINIT APPUT APWD \$COS \$EXP \$SIN

TOTAL SPACE ALLOCATED = 021640 4560

,GLOBAL=GLOBAL

>

```

0001      SUBROUTINE LEAF
0002      REAL MNEW,MOLD,NORM,AOLD(16),AKRNL(16,16),B(2),XJ(16),ZJ(16),
1 JNEWK(16),JO(1536),ANEW(16),AJOLDK(16),AKRN(256)
0003      INTEGER SN1Z,SINFZ,COSFZ,DELZ,AZ,S1Z,S2Z,T1Z,T2Z
0004      INTEGER MEM(6),KADR(16)
0005      INTEGER COSF,SINF,CEIL,AGOOLD,AMOLD,AGONEW,AMNEW
0006      INTEGER AAOLD,AANEW,ASC1,ASC2,ASC3,AA2R,AXP1,AADLT
0007      INTEGER ASS
0008      INTEGER AXP2,AGA,ACLF,AAM1,AAM2,AZJ,AXJ,ANORM,ASJ
0009      REAL A(2),FMEM(6)

C THIS COMMON CONTAINS THE PRINT FLAGS-SPECIFICALLY JPRNT AND KOUNT
C DATA TYPE'D AT BOTTOM OF THIS ROUTINE IF MOD(KOUNT,JPRNT) IS ZERO
0010      COMMON/PRINTC/IPRNT,JPRNT,KPRNT,KOUNT
0011      COMMON M,N,KMAX,A11,A22,Q33C,PIDLT,ALF,DELT,CONST,R11,
1 MNEW,MOLD,GONEW,GOOLD,PI,TWOPI,Y1EST,Y2EST,Y3EST,
2 CHAT,SHAT,XHAT,NORM,JO,Z1,Z2,
3 COSY(16),SINY(16),AM1
0012      COMMON INFLAG,LCHAT,LSHAT,SN1Z,COSFZ,SINFZ,DELZ,JNSZ,JZZ,
1 MEMS,AZ,S1Z,S2Z,INBUFZ,T1Z,T2Z,ITOPS,ALDLT,GA,Q33,COSF,
2 SINF,KBIAS,CEIL,AGOOLD,AMOLD,AGONEW,AMNEW,AAOLD,AANEW,ASC1,
3 ASC2,ASC3,AA2R,AXP1,AADLT,AGA,AXP2,ACLF,AAM1,AAM2,AZJ,AXJ,
4 ANORM,ASJ,ASS
C ***** START LEAF MODULE *****
0013      X1=SECNDS(0.0)
0014      IDEV=5
0015      T1=SECNDS(X1)
0016      CALL VRAMP(AGOOLD,AMOLD,ASC1,1,KMAX)
0017      CALL APWR
0018      CALL VSADD(ASC1,1,AMOLD,AAOLD,1,KMAX)
0019      CALL APWR
0020      CALL VRAMP(AGONEW,AMNEW,ASC2,1,KMAX)
0021      CALL APWR
0022      CALL VSADD(ASC2,1,AMNEW,AANEW,1,16)
0023      CALL APWR
0024      IIII=ASS+2*M
0025      IV=IIII+1
0026      XX1=-1.
0027      CALL APPUT(XX1,IIII,1,2)
0028      CALL APWD
0029      CALL VSADD(AAOLD,1,IIII,ASC2,1,16)
0030      CALL APWR
0031      CALL VEXP(ASC2,1,IV,1,16)
0032      CALL APWR
0033      CALL VSQ(IV,1,ASC1,1,KMAX)
0034      CALL APWR
0035      CALL VSMUL(ASC1,1,AXP1,ASC2,1,KMAX)
0036      CALL APWR
0037      CALL VEXP(ASC2,1,AA2R,1,KMAX)
0038      CALL APWR
0039      T2=SECNDS(X1)
0040      JZ=ITOPS
0041      MEM(1)=JZ+M*N-1
0042      MEM(2)=MEM(1)
0043      MEM(3)=JZ+M*N
0044      MEM(4)=JZ

```

LEAF.FTN

/TR:BLOCKS/WR

```

0045      MEM(5)=JZ+M*N-4*M-1
0046      MEM(6)=JZ-1
0047      B(1)=Z1
0048      B(2)=Z2
0049      CALL APPUT(B,18,2,2)
0050      AAA=FLOAT(KBIAS)
0051      II=ASS+3
0052      CALL APPUT(AAA,II,1,2)
0053      FMEM(1)=FLOAT(MEM(1))
0054      FMEM(2)=FLOAT(MEM(2))
0055      FMEM(3)=FLOAT(MEM(3))
0056      FMEM(4)=FLOAT(MEM(4))
0057      FMEM(5)=FLOAT(MEM(5))
0058      FMEM(6)=FLOAT(MEM(6))
0059      III=ASS+4
0060      CALL APPUT(FMEM,III,6,2)
0061      CALL APWD
0062      CALL LC(III,II,KBIAS,IV,INBUFZ,AA2R,ASC1)
0063      CALL APWR
0064      T3=SECNDS(X1)
0065      AB=NORM
0066      TNORM=1./AB
0067      CALL APPUT(TNORM,ANORM,1,2)
0068      CALL APWD
0069      CALL ME(AANEW,AAOLD,ASC1,AADLT,ASC2,ASC3,AGA,AXP2,ACLF,ANORM)
0070      CALL APWR
0071      T4=SECNDS(X1)
0072      CALL TTMOV(ACLF,4608,256)
0073      CALL APWR
0074      T5=SECNDS(X1)
C ***** END LEAF MODULE *****
0075      DO 600 K=1,16
0076      600  XJ(K)=0.0
0077      DO 609 K=1,16
0078      609  CALL APPUT(XJ,ITOPS+M*N+(K-1)*M*(N+1),16,2)
0079      CALL APWD
C ***** START ACON MODULE *****
C      DOES AMPLITUDE CUNVOLUTION FOR EACH I,J
0080      T6=SECNDS(X1)
0081      CALL W
0082      CALL APWR
0083      T7=SECNDS(X1)
0084      CALL XSUM(ITOPS,M,AXJ,KBIAS)
0085      CALL APWR
0086      CALL ZSUM(ITOPS,M,AZJ,KBIAS)
0087      CALL APWR
0088      T8=SECNDS(X1)
0089      CALL DOTPR(AXJ,1,COSFZ,1,ASS,M)
0090      CALL DOTPR(AXJ,1,SINFZ,1,ASS+1,M)
0091      CALL DOTPR(AZJ,1,AANEW,1,AAM1,KMAX)
0092      CALL VSQ(AANEW,1,ASC1,1,KMAX)
0093      CALL DOTPR(ASC1,1,AZJ,1,AAM2,KMAX)
0094      CALL SVE(AZJ,1,ANORM,KMAX)
0095      CALL APWR
0096      CALL APGET(A,ASS,2,2)
0097      CALL APGET(Y,AAM1,1,2)

```



```

0098      CALL APGET(YY,AAM2,1,2)
0099      CALL APGET(ABL,ANORM,1,2)
0100      CALL APWD
0101      T0=SECNDS(X1)-T8
0102      KHAT=ATAN2(A(2),A(1))
0103      NORM=ABL
0104      AM1=Y/ABL
0105      AM2=YY/ABL
0106      CALL VMOV(AGONEW,1,AGOOLD,1,2)
0107      CALL APWR
0108      S1=AMAX1(AM2-AM1**2,1.E-18)
0109      S1=SQRT(S1)
0110      GONEW=(-.5-FLOAT(KMAX)/2.)*(1./2.)*S1+AM1
0111      MNEW=.5*S1
0112      CALL APPUT(GONEW,AGONEW,1,2)
0113      CALL APPUT(MNEW,AMNEW,1,2)
0114      CALL APWD
C ***** END ACON MODULE *****
0115      T9=SECNDS(X1)
0116      IF(MOD(KOUNT,JPRNT).EQ.0)TYPE *,T1,T2-T1,T3-T2,T4-T3,T5-T4,T6-T5
X      ,T7-T6,T8-T7,T9-T8,T9
0117      IF(MOD(KOUNT,JPRNT).EQ.0)TYPE *,TO
0118      RETURN
0119      END

```

PROGRAM SECTIONS

NUMBER	NAME	SIZE	ATTRIBUTES
1	\$CODE1	002462 665	RW,I,CON,LCL
2	\$PDATA	000044 18	RW,D,CON,LCL
3	\$IDATA	000636 207	RW,D,CON,LCL
4	\$VARS	005062 1305	RW,D,CON,LCL
6	PRINTC	000010 4	RW,D,OV,GBL
7	.\$\$\$\$.	014510 3236	RW,D,OV,GBL

ENTRY POINTS

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
LEAF		1-000000						

VARIABLES

NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS	NAME	TYPE	ADDRESS
AAA	R*4	4-004754	AADLT	I*2	7-014462	AAM1	I*2	7-014472
AAM2	I*2	7-014474	AANEW	I*2	7-014446	AAOLD	I*2	7-014444
AA2R	I*2	7-014456	AB	R*4	4-004770	ABL	R*4	4-005036
ACLF	I*2	7-014470	AGA	I*2	7-014464	AGONEW	I*2	7-014440
AGOOLD	I*2	7-014434	ALDLT	R*4	7-014410	ALF	R*4	7-000026
AMNEW	I*2	7-014442	AMOLD	I*2	7-014436	AM1	R*4	7-014342
AM2	R*4	4-005046	ANORM	I*2	7-014502	ASC1	I*2	7-014450
ASC2	I*2	7-014452	ASC3	I*2	7-014454	ASJ	I*2	7-014504
ASS	I*2	7-014506	AXJ	I*2	7-014500	AXP1	I*2	7-014460
AXP2	I*2	7-014466	AZ	I*2	7-014372	AZJ	I*2	7-014476
Al1	R*4	7-000006	A22	R*4	7-000012	CEIL	I*2	7-014432
CHAT	R*4	7-000112	CONST	R*4	7-000036	COSF	I*2	7-014424
COSFZ	I*2	7-014356	DELT	R*4	7-000032	DELZ	I*2	7-014362
GA	R*4	7-014414	GONEW	R*4	7-000056	GOOLD	R*4	7-000062
IDEV	I*2	4-004730	II	I*2	4-004760	III	I*2	4-004762
IIII	I*2	4-004736	INBUFZ	I*2	7-014400	INFLAG	I*2	7-014346
IPRNT	I*2	6-000000	ITOPS	I*2	7-014406	IV	I*2	4-004740
JNSZ	I*2	7-014364	JPRNT	I*2	6-000002	JZ	I*2	4-004752
JZZ	I*2	7-014366	K	I*2	4-005010	KBIAS	I*2	7-014430
KMAX	I*2	7-000004	KOUNT	I*2	6-000006	KPRNT	I*2	6-000004
LCHAT	I*2	7-014350	LSHAT	I*2	7-014352	M	I*2	7-000000
MEMS	I*2	7-014370	MNEW	R*4	7-000046	MOLD	R*4	7-000052
N	I*2	7-000002	NORM	R*4	7-000126	PI	R*4	7-000066
PIDL	R*4	7-000022	Q33	R*4	7-014420	Q33C	R*4	7-000016
R11	R*4	7-000042	SHAT	R*4	7-000116	SINF	I*2	7-014426
SINFZ	I*2	7-014360	SN1Z	I*2	7-014354	S1	R*4	4-005052
S1Z	I*2	7-014374	S2Z	I*2	7-014376	TNORM	R*4	4-004774
TWOPI	R*4	7-000072	TO	R*4	4-005042	T1	R*4	4-004732
T1Z	I*2	7-014402	T2	R*4	4-004746	T2Z	I*2	7-014404
T3	R*4	4-004764	T4	R*4	4-005000	T5	R*4	4-005004
T6	R*4	4-005012	T7	R*4	4-005016	T8	R*4	4-005022
T9	R*4	4-005056	XHAT	R*4	7-000122	XX1	R*4	4-004742
X1	R*4	4-004724	Y	R*4	4-005026	YY	R*4	4-005032

Y1EST R\*4 7-000076 Y2EST R\*4 7-000102 Y3EST R\*4 7-000106  
Z1 R\*4 7-014132 Z2 R\*4 7-014136

ARRAYS

NAME	TYPE	ADDRESS	SIZE	DIMENSIONS
A	R*4	4-004664	000010	4 (2)
AJOLDK	R*4	4-002510	000100	32 (16)
AKRN	R*4	4-002610	002000	512 (256)
AKRNL	R*4	4-000100	002000	512 (16,16)
ANew	R*4	4-002410	000100	32 (16)
AOLD	R*4	4-000000	000100	32 (16)
B	R*4	4-002100	000010	4 (2)
COSY	R*4	7-014142	000100	32 (16)
FMEM	R*4	4-004674	000030	12 (6)
JNEWK	R*4	4-002310	000100	32 (16)
JO	R*4	7-000132	014000	3072 (1536)
KADR	I*2	4-004624	000040	16 (16)
MEM	I*2	4-004610	000014	6 (6)
SINY	R*4	7-014242	000100	32 (16)
XJ	R*4	4-002110	000100	32 (16)
ZJ	R*4	4-002210	000100	32 (16)

LABELS

LABEL	ADDRESS	LABEL	ADDRESS	LABEL	ADDRESS
600	**	609	**		

FUNCTIONS AND SUBROUTINES REFERENCED

APGET	APPUT	APWD	APWR	DOTPR	LC	ME	SECNDS	SVE	TTMOV
VEXP	VMOV	VRAMP	VSADD	VSMUL	VSQ	W	XSUM	ZSUM	\$AMAX1
\$ATAN2	\$SQRT								

TOTAL SPACE ALLOCATED = 025166 5435

,LEAF=LEAF

>



```

DEFINE LC(III,II,KBIAS,AANEW,INBUFZ,AA2R,ASC1)
LOCAL K,A,B
K=0
CALL VFIX(III,1,1,1,6)
LOOP:A=AANEW+K
B=AA2R+K
CALL VSMUL(18,1,A,INBUFZ,1,2)
CALL VMOV(B,1,7,1,1)
CALL VSADD(III,1,II,ASC1,1,6)
CALL VMOV(ASC1,1,III,1,6)
CALL RLNLF(0)
CALL VFIX(ASC1,1,1,1,6)
K=K+1
IF K<16 GOTO LOOP
END

```

```

"RLNLF.FSO
"DIC.FSO FAST 2-LOOP BOX
"DOES FILTER(FRANK), THEN
"CONVOLVE(JACK).
"INITSW=0 FIRST CALL-ONLY DOES CONVOLVE.
"INITSW=0 FIRST FILTER CALL
"=1 REST OF FILTER CALLS
"=2 CONVOLVE CALL
"INITSW=1 FOR EACH ESTIMATE.
"REMOVE HALT BETWEEN FILTER,CONVOLVE
"VERSION
"3-8-78 HALT IM MIDDLE
"RLNLEH16 TO RLNLFE3D
"3-8-78
"CALLS EXPDO
"NEXTMD -ADDRESSING ENTRY FOR EXPDO
"LD NORM FROM MD IN FRANK
"HALT AFTER FRANK

$TITLE RLNLF
$ENTRY RLNLF,1 "CALL NLF(INITSW=CHECK)
$ENTRY NEXTMD "SP(0):=NEXT FREE MD ADDR.
$EXT EXPDO "DO EXP IN BOX

```

# "SIZING

```

MV $EQU 16.
NV $EQU 96.
MNV $EQU MV*NV
SNIZV $EQU 20.
COSFZ $EQU SNIZV+MV
SINFZ $EQU COSFZ+MV
DELZ $EQU SINFZ+MV
JNSZZ $EQU DELZ+NV
JZZ $EQU JNSZZ+NV
MEMS $EQU JZZ+MNV+MV
AZ $EQU MEMS+11.
NXFREE $EQU AZ+11.

```

## "TABLE MEMORY ADDRESSES

```

JTMA $EQU 10000
NORLV $EQU JTMA+NV+11.
"MN1V $EQU MNV+JZ-1
"MN2V $EQU MNV+JZ
XINCV $EQU 1
M1V $EQU MV-1
TWV $EQU 2
MNV $EQU TWV*MV
"MNV $EQU MNV+JZ-1
CHATV $EQU 18.
SHATV $EQU 19.
CHECKV $EQU 0

```

"S PAD ADDRESSES

"GLOBAL CONSTANTS

M \$EQU 1  
N \$EQU 2  
MN \$EQU 3

"FOR FILTER

ICNT \$EQU 3  
MNN \$EQU 4  
JCNT \$EQU 4     "C+  
MN1 \$EQU 5  
JFI \$EQU 5  
M2 \$EQU 6  
XINC \$EQU 7  
JRA \$EQU 7  
JNSRA \$EQU 8.  
JWA \$EQU 8.  
M1 \$EQU 9.  
MM \$EQU 10.  
MN2 \$EQU 11.  
TW \$EQU 12.  
JBI \$EQU 12.  
JNSZ \$EQU 13.  
COSFA \$EQU 13.  
NORL \$EQU 14.  
CHAT \$EQU 14.  
SINFA \$EQU 14.  
INITSW \$EQU 0     "C+.  
SNIZ \$EQU 0

RLNLF:NOP

JSR EXPDO  
JMP ENTER1

NEXTMD: LDSPI 0;DB=NXFREE

RETURN

NOP  
NOP

"RETURN SP(0):=NEXT FREE MD ADDR.

ENTER1:LDMA;

DB=2

NOP

LDMA;

DB=3

LDSPI MNN;

DB=MD

LDSPI MN1;

DB=MD

LDSPI MN2;

DB=MD

NOP

NOP

"MAIN ENTRY FROM HOST



```

LDSP1 M;
DB=MV

LDDA;
DB=5

LDSP1 N;
DB=NV

LDSP1 MN;
DB=MNV

LDSP1 JNSRA;
DB=JZZ

LDSP1 XINC;
DB=XINCV

LDSP1 M1;
DB=M1V

LDSP1 MM;
DB=MMV

LDSP1 TW;
DB=TWV

LDSP1 JNSZ;
DB=JNSZZ

LDSP1 NORL;
DB=NORLV

MOV INITSW,INITSW

BEQ FIRST

LDSP1 15;DB=2      "IF INITSW=2 GOTO CONVOL
SUB 15,INITSW
BNE NXLABEL
JMP CONVOL
NXLABEL: JMP SECOND "ELSE GOTO NON-FIRST FILTER

FIRST:LDDPA;
DB=10.

LDTMA;DB=!ONE      "TM(SP(NORL)):- 1.0
NOP

DPX<TH

MOV NORL,NORL;
SETMA;
OUT;
DB=DPX

LDTMA;
DB=JTMA+10.

```

```

        LDMA;
        DB=DELZ

        "STO N DELJ IN TM
        MOV N,JCNT

LPI:INCMA
        INCTMA;
        OUT;
        DB=MD

        DEC JCNT

        BGT LPI

        LDSPI SNIZ;DB=SNIZV

        JMP ST1          "DO ONLY CONVOLVE FIRST TIME
                          "DO FRANK

SECOND:LDDPA;          "BEGIN FILTER
        DB=10.

        LDSPI 0;DB=CHATV-1      "ADDR OF NORM
        MOV 0,0;SETMA
        NOP
        NOP
        MOV NORL,NORL;
        SETTMA;
        OUT;
        DB=MD          "NORM

ST1:LDMA;          "NORM**EXP(-A**2/2*R)--> NORM
        DB=7

        LDDPA;
        DB=0

        LDMA;
        DB=1ONE
        "MOV NORL,NORL;
        "SETTMA

        LDMA;DB=2

        DPX<MD

        NOP

        FMUL TM,DPX

        LDSPI MNN;DB=MD

        FMUL

        FMUL

```

```

DPX<FM

MOV NORL,NORL;
  SETTMA;
  OUT;
  DB=DPX

"STO M SN IN DPX & DPY

LPCYC:LDSP1 SNIZ;
  DB=SNIZV

LP2:MOV SNIZ,SNIZ;
  SETMA

MOV NORL,NORL;
  SETTMA

INC SNIZ

FMUL TM,MD

FMUL

FMUL;
  DEC M

DPX(0)<FM,DPY(0)<FM

INCDPA

BGT LP2

LDSP1 M;
  DB=MV

DEC TW

BGT LPCYC

LDSP1 TW;
  DB=TWV

LDTMA;
  DB=JTMA+NV+11.
LDSP1 M;
  DB=MV

LOOP:DEC JNSRA
MOV JNSRA,JNSRA;
  SETMA

NOP

NOP

LDSP1 JNSZ;
  DB=MD

```



DECTMA	
AND# XINC,JNSZ	
BEQ BIELP	
JMP BIOLP	
BIELP:ADD# XINC,JNSZ;	
SETDPA	
SUB 1,5	
SUB 1,11.	
ADD# MN1,JNSZ;	
SETMA	"GET J1
INC JNSZ	
MOVR 1,6	"M2-16.
AND M1,JNSZ;	
FMUL DPX(-2),MD	"J1*SN1--->J1
ADD# MN1,JNSZ;	
SETMA;	"GET J2
FMUL	
FMUL	
ADD# MN2,JNSZ;	"GET J3
SETMA;	
DPY(-2)<FM	"STO J1 IN DPY 0
ADD TW,JNSZ;	
FMUL DPY(-1),MD	"J2*SN2--->J2
FMUL;	
INCDPA	
FMUL DPX(-1),MD	"J3*SN3--->J3
FMUL;	
DPX(-2)<FM;	"STO J2 IN DPX 1
INCDPA	
AND M1,JNSZ;	
FMUL	
ADD# MN1,JNSZ;	"GET J4
SETMA;	
DPY(-2)<FM	"STO J3 IN DPY 2
NOP	
ADD# MN2,JNSZ;	"GET J5
SETMA	
ADD TW,JNSZ;	
FMUL DPY(-1),MD	"J4*SN4--->J4
FMUL	109

FMUL DPX(0),MD	"J5*SN5--->J5
FSUB DPX(-3),DPY(-4)	"J2-J1
FMUL;	
DPX(-1)<FM;	"STO J4 IN DPX 3
FADD	
IELP:AND M1,JNSZ;	"CHECK IF JNSZ IS 32
FMUL TM,FA;	"DELJ*(J2-J1)
FSUB DPY(-2),DPX(-3)	"J3-J2
ADD# MN1,JNSZ;	"GET J6
SETMA;	
DPY(0)<FM;	"STO J5 IN DPY 4
FMUL;	
FADD	
FMUL TM,FA	"DELJ*(J3-J2)
ADD# MN2,JNSZ;	"GET J7
SETMA;	
FADD FM,DPY(-4);	"DELJ*(J2-J1)+J1
FMUL	
ADD TW,JNSZ;	
FMUL DPY(1),MD;	"J6*SN6--->J6
FADD	
FMUL;	
FADD FM,DPX(-3);	"DELJ*(J3-J2)+J2
INCDPA;	
INC MNN;	
SETMA;	
MI<FA	
FMUL DPX(1),MD	
FSUB DPX(-2),DPY(-3);	"J4-J3
DEC M2	
FMUL;	
DPX(0)<FM;	"STO J6 IN DPX 5
INCDPA;	
FADD;	
INC MNN;	
SETMA;	
MI<FA;	
BGT IELP	
SUB 10.,4	
JMP STEP	
BIOLP:ADD# XINC,JNSZ;	
SETDPA	

```

SUB 1,5

SUB 1,11.

ADD# MN1,JNSZ;
  SETMA

INC JNSZ

MOVR 1,6

ADD# MN1,JNSZ;
  SETMA;
  FMUL DPY(-2),MD

AND M1,JNSZ

  ADD# MN2,JNSZ;
  SETMA;
  FMUL

ADD TW,JNSZ;
  FMUL DPX(-1),MD

FMUL;
  DPX(-2)<FM;
  INCDPA

FMUL DPY(-1),MD

FMUL;
  DPY(-2)<FM;
  INCDPA

FMUL

DPX(-2)<FM;
  ADD# MN1,JNSZ;
  SETMA

AND M1,JNSZ

ADD# MN2,JNSZ;
  SETMA

ADD TW,JNSZ;
  FMUL DPX(-1),MD

FMUL;
  FSUB DPY(-3),DPX(-4)

FMUL DPY(0),MD

FMUL;
  DPY(-1)<FM;
  FADD

IOLP:FMUL TM,FA;
  FSUB DPX(-2),DPY(-3)

```



```

ADD# MN1,JNSZ;
SETMA;
DPX(0)<FM;
FADD;
FMUL

```

```

AND M1,JNSZ;
FMUL TM,FA

```

```

ADD# MN2,JNSZ;
SETMA;
FADD FM,DPX(-4);
FMUL

```

```

ADD TW,JNSZ;
FMUL DPX(1),MD;
FADD

```

```

FMUL;
FADD FM,DPY(-3);
INCDPA;
INC MNN;
SETMA;
MI<FA

```

```

FMUL DPY(1),MD

```

```

FSUB DPY(-2),DPX(-3);
DEC M2

```

```

FMUL;
DPY(0)<FM;
INCDPA;
FADD;
INC MNN;
SETMA;
MI<FA;
BCT IOLP

```

```

SUB 10.,4

```

```

STEP:DEC N

```

```

BEQ ASTEP
JMP LOOP          "END MAIN FILTER LOOP

```

```

ASTEP:NOP

```

```

CONVOL: NOP          "BEGIN CONVOLVE
NOP

```

```

LDSPI COSFA; DB=COSEZ+MV
LDSPI SINFA;DB=SINFZ+MV
"NORM IS READ INTO MA 10 EACH TIME
"START CONVOLUTION LOOP
LDSPI M;DB=MV
LDSPI N;DB=NV
LDDPA;
DB=9.

```

DB=ZERO;  
DPX<DB;  
DPY<DB

LDMA;  
DB=5

DB=ZERO;  
DPX(1)<DB

MOV M,ICNT

LDSPJ JBI;  
DB=MD

LDDPA;DB=5

LDDA;  
DB=5

LDMA;  
DB=AZ

NOP

INCMA

DPX(-2)<DB;  
DB=MD

INCMA

DPY(-3)<DB;  
DB=MD

DPX(-3)<DB;  
DB=MD

INCMA

DPX(-3)<DB;  
DB=MD

INCMA

DPY(-4)<DB;  
DB=MD

NOP

DPX(-4)<DB;  
DB=MD

LDMA;  
DB=6

NOP

NOP

LDSPJ JFI;  
DB=MD

I2LP:LDDPA;DB=5

DB=ZERO;  
DPY(-2)<DB

INC JFI  
MOV JFI,JWA

INC JBI

LDSPJ JCNT;  
DB=5

SUB M,JWA  
LDMA;

"ZERO TROW

DB=JTMA-1

"SAVE 5 FRONT END VALUES IN TM

MOV JFI,JRA

ADD M,JRA;SETMA

NOP

ADD M,JRA;  
SETMA

J2LP:INCTMA;

OUT;  
DB=MD;  
DEC JCNT

ADD M,JRA;  
SETMA;  
BGT J2LP

LDSPI JCNT;  
DB=4

"READ 5 FROM BACK NO WRITE

MOV JBI,JRA;  
SETMA

NOP

NOP

FMUL DPX(-2),MD

FMUL DPY(-3),MD

FMUL

FMUL DPX(-3),MD;  
FADD FM,DPY(3)

FMUL DPY(-4),MD;  
FADD FM,DPX(3)

FADD

FMUL;  
FADD FM,DPX(2);  
DPY(3)<FA

FMUL DPX(-4),MD;  
FADD FM,DPY(2)

FMUL DPY(-4),MD;  
FADD FM,DPX(1);  
DPX(3)<FA

J3LP:FMUL DPX(-3),MD;

"GET FIRST J IN

"GET SECOND J IN

"GET J

"A5\*J

"A4\*J

"A3\*J  
"(A5\*J)+S10 (=J1)

"A2\*J  
"(A4\*J)+S9 (=S10)

"(A3\*J)+S8 (=S9)  
"STO S10

"A1\*J  
"(A2\*J)+S7 (=S8)

"A2\*J  
"(A1\*J)+S6 (=S7)  
"STO S9

"A3\*J



FADD DPY(1),MD;  
DPX(2)<FA;  
ADD M,JRA;  
SETMA

FMUL DPY(-3),MD;  
FADD FM,DPX(0);  
DPY(2)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(0);  
DPX(1)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(-1);  
DPY(1)<FA

FMUL DPY(-3),MD;  
FADD FM,DPX(-1);  
DPX(0)<FA

FMUL;FADD;  
DPX(-1)<FM;  
DPY(0)<FA

FMUL DPX(-3),MD;  
FADD FM,DPY(3)

FMUL DPY(-4),MD;  
FADD FM,DPX(3);  
DPY(-1)<FA

FMUL DPX(-4),MD;FADD

FMUL;  
FADD FM,DPX(2);  
DPY(3)<FA

FMUL DPX(-4),MD;  
FADD FM,DPY(2);  
DEC JCNT

FMUL DPY(-4),MD;  
FADD FM,DPX(1);  
DPX(3)<FA;  
BCT J3LP

"READ 5 FROM FRONT, NO WRITE

LDSPI JCNT;  
DB=5

MOV JFI,JRA

J4LP: FMUL DPX(-3),MD;  
FADD DPY(1),MD;  
DPX(2)<FA;  
ADD M,JRA;  
SETMA

"S5+J (-S6)  
"STO S8  
"GET NEXT J

"A4\*J  
"(A1\*J)+S4 (-S5)  
"STO S7

"A5\*J (-S1)  
"(A2\*J)+S3 (-S4)  
"STO S6

"A5\*J1  
"(A3\*J)+S2 (-S3)  
"STO S6

"A4\*J1  
"(A4\*J)+S1 (-S2)  
"STO S4

"STO S1  
"STO S3

"A3\*J1  
"(A5\*J1)+S10 (-J)

"A2\*J1  
"(A4\*J)+S9 (-S10)  
"STO S2

"A1\*J1

"(A3\*J1)+S8 (-S9)  
"STO S10

"A1\*J1  
"(A2\*J1)+S7 (-S8)

"A2\*J1  
"(A1\*J1)+S6 (-S7)  
"STO S9

FMUL DPY(-3),MD;  
FADD FM,DPX(0);  
DPY(2)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(0);  
DPX(1)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(-1);  
DPY(1)<FA

FMUL DPY(-3),MD;  
FADD FM,DPX(-1);  
DPX(0)<FA

FMUL;FADD;  
DPX(-1)<FM;  
DPY(0)<FA

FMUL DPX(-3),MD;  
FADD FM,DPY(3)

FMUL DPY(-4),MD;  
FADD FM,DPX(3);  
DPY(-1)<FA

FMUL DPX(-4),MD;FADD

FMUL;  
FADD FM,DPX(2);  
DPY(3)<FA

FMUL DPX(-4),MD;  
FADD FM,DPY(2);  
DEC JCNT

FMUL DPY(-4),MD;  
FADD FM,DPX(1);  
DPX(3)<FA;  
BGT J4LP

"READ N-5 FROM MIDDLE, WITH WRITE

LDSPI JCNT;  
DB=NV-5

J5LP:FMUL DPX(-3),MD;  
FADD DPY(1),MD;  
DPX(2)<FA;  
ADD M,JRA;  
SETMA

FMUL DPY(-3),MD;  
FADD FM,DPX(0);  
DPY(2)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(0);  
DPX(1)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(-1);  
DPY(1)<FA

FMUL DPY(-3),MD;  
FADD FM,DPX(-1);  
DPX(0)<FA

FMUL;FADD;  
DPX(-1)<FM;  
DPY(0)<FA

FMUL DPX(-3),MD;  
FADD FM,DPY(3)

FMUL DPY(-4),MD;  
FADD FM,DPX(3);  
DPY(-1)<FA

FMUL DPX(-4),MD  
FADD DPY(-2),FA;  
ADD M,JWA;  
SETMA;  
MI<FA

FMUL;  
FADD FM,DPX(2);  
DPY(3)<FA

FMUL DPX(-4),MD;  
FADD FM,DPY(2);  
DPY(-2)<FA;  
DEC JCNT

FMUL DPY(-4),MD;  
FADD FM,DPX(1);  
DPX(3)<FA;  
BCT J5LP

"READ 5 FROM TM STORE,WRITE

LDTMA;  
DB=JTMA-1  
LDSPI JCNT;DB=5

J6LP:FMUL DPX(-3),MD;  
FADD DPY(1),MD;  
DPX(2)<FA;  
INCTMA

FMUL DPY(-3),MD;  
FADD FM,DPX(0);  
DPY(2)<FA

FMUL DPX(-2),MD;  
FADD FM,DPY(0);  
DPX(1)<FA

FMUL TM,DPX(-2);  
FADD FM,DPY(-1);  
DPY(1)<FA



FMUL TM,DPY(-3);  
FADD FM,DPX(-1);  
DPX(0)<FA

FMUL;FADD;  
DPX(-1)<FM;  
DPY(0)<FA

FMUL TM,DPX(-3);  
FADD FM,DPY(3)

FMUL TM,DPY(-4);  
FADD FM,DPX(3);  
DPY(-1)<FA

FMUL TM,DPX(-4);  
FADD DPY(-2),FA;  
ADD M,JWA;  
SETMA;  
MI<FA

FMUL;  
FADD FM,DPX(2);  
DPY(3)<FA

FMUL TM,DPX(-4);  
FADD FM,DPY(2);  
DPY(-2)<FA;  
DEC JCNT

FMUL TM,DPY(-4);  
FADD FM,DPX(1);  
DPX(3)<FA;  
BGT J6LP

"FINISH ROW OPERATIONS

SUB# ICNT,COSFA;  
SETMA

"GET COS

LDDPA;  
DB-7

SUB# ICNT,SINFA;  
SETMA

"GET SIN

FMUL DPY(-4),MD

FADD DPX(3),DPY(-4);  
FMUL

FMUL DPY(-4),MD;  
FADD

FADD FM,DPY(2);  
DPX(3)<FA;  
FMUL

FADD;  
FMUL

FADD FM,DPX(2);  
DPY(2)<FA

FADD  
DPX(2)<FA  
DEC ICNT  
BEQ STEP2  
JMP I2LP  
STEP2:RETURN  
\$END

>

```

$TITLE EXPDO
$ENTRY EXPDO
$EXT NEXTMD "IN RLNL - RETURNS ADDR IN MD
"<SN1> := EXP(Z1*<S1>+Z2*<S2>)
"VERSION 1-25-78
"NEW SPAD-TM
"MV.
"+SP4 :=1
"REMOVE SPFTMA

```

```

$EXT VSMUL,VADD,VEXP "LINK FROM APLIB.FRB
MV = 16.

```

```

SN1Z = 20.
"MD ADDRESSES (RELATIVE TO NEXTMD)
S1Z = 0.
S2Z = S1Z+MV
INBUF = S2Z+MV
Z1Z = INBUF
Z2Z = Z1Z+1

```

```

T1Z = Z2Z+1
T2Z = T1Z+MV
"NEXT FREE = T2Z+MV

```

```

STMADR = 10500K "START SAVE ADDR IN TM FOR SPAD

```

```

EXPDO: NOP
MOV 0,0; DPX<SPFN
LDSPI 0;DB=0.
MOV 0,0;SETMA; MI<DPX "MD(0):=INITSW
NOP

```

```

JSR NEXTMD
LDSPI 1;DB=1
LDSPI 2;DB=Z1Z
ADD 0,2 "GET ABSOLUTE ADDR
LDSPI 3; DB=T1Z
ADD 0,3
LDSPI 4; DB=1
LDSPI 5; DB=MV
JSR VSMUL "<T1> = <S1>*Z1

```

```

JSR NEXTMD
LDSPI 1;DB=1
LDSPI 2; DB=Z2Z
ADD 0,2
LDSPI 3; DB=T2Z
ADD 0,3
LDSPI 4; DB=1
LDSPI 5; DB=MV
LDSPI 6;DB=S2Z
ADD 0,6
MOV 5,0
JSR VSMUL "<T2> = <S2>*Z2

```



```

JSR NEXTMD
LDSPI 1;DB=1
LDSPI 2; DB=T2Z
ADD 0,2
LDSPI 3; DB=1
LDSPI 4; DB=SN1Z
LDSPI 5; DB=1
LDSPI 6; DB=MV
LDSPI 7;DB=T1Z
ADD 0,7
MOV 7,0
JSR VADD      "<SN1> = <T1>+<T2>"

LDSPI 0; DB=SN1Z
LDSPI 1;DB=1
LDSPI 2; DB=SN1Z
LDSPI 3; DB=1
LDSPI 4; DB=MV
JSR VEXP      "<SN1> = EXP(<SN1>)"

LDMA; DB=0.   "RESTORE INITSW FROM MD(0)"
NOP
NOP
NOP
LDSPI 0;DB=MD
NOP
RETURN
$END

```

```

DEFINE ME(AANEW,AAOLD,ASC1,AADLT,ASC2,ASC3,AGA,AXP2,ACLF,ANORM)
LOCAL K,KM,B,D
K=16
KM=240
B=AAOLD+15
LOOP:CALL VFILL(B,ASC1,1,16)
CALL VSMUL(ASC1,1,AGA,ASC2,1,16)
CALL VFILL(AADLT,ASC3,1,16)
CALL VADD(ASC3,1,ASC2,1,ASC1,1,16)
CALL VADD(ASC1,1,AANEW,1,ASC2,1,16)
CALL VSQ(ASC2,1,ASC1,1,16)
CALL VSMUL(ASC1,1,AXP2,ASC2,1,16)
CALL VEXP(ASC2,1,ASC3,1,16)
D=ACLF+KM
CALL VSMUL(ASC3,1,ANORM,D,1,16)
B=B-1
KM=KM-16
K=K-1
IF K>0 GOTO LOOP
END

```

>

```

$TITLE TTMOV
$ENTRY TTMOV,3
A $EQU 0
C $EQU 1
N $EQU 2
TTMOV:MOV A,A;SETMA
      DEC C;SETMA
      INCMA
      LDA;
      DB=5
LOOP:INCMA;
      DPX<=D;
      DEC N
      OUT;DB=DPX;INCTMA;
      BNE LOOP
      RETURN
$END

```

>



```

"W.FSO
$TITLE W
$ENTRY W,0
$EXT STHIRD
"S PAD ADDRESSES
  B $EQU 0
  I $EQU 8.
  J $EQU 9.
  NJ $EQU 10.
W:LDSP I;
  DB=96.
  LDSPI NJ;
  DB=1908.

LOOPI:LDSP I J;DB=16.
LOOPJ:MOV NJ,B

  JSR STHIRD

  INC NJ

  DEC J

  BGT LOOPJ

  DEC I

  BGT LOOPI

  RETURN

$END
>

```

```

"STHIRD.FSO
$TITLE STHIRD
$ENTRY STHIRD,1

"SIZING
MV $EQU 16.
NV $EQU 96.
MNIV $EQU MV*NIV-MV
"TABLE MEMORY ADDRESSES
  ISTAT $EQU 11000
"S PAD ADDRESSES
  ITOPS $EQU 0
  M $EQU 1
  MN1 $EQU 2
  KBIAS $EQU 3
  MKK $EQU 4
  MK $EQU 5
  TMINC $EQU 6
STHIRD:LDSP1 KBIAS;
      DB=0

```

```

LDSP1 M;
  DB=MV

```

```

LDSP1 MK;
  DB=MV
LDSP1 MN1;
  DB=MNIV

```

```

LDSP1 TMINC;
  DB=ISTAT

```

```

LDTMA;
  DB=!ZERO

```

```

LDDPA;
  DB=0

```

```

DPX(0)<TM;
DPY(0)<TM;
DEC MK

```

```

LPDPXY:DPX(0)<TM;
DPY(0)<TM;
DEC MK;
INCDPA;
BGT LPDPXY

```

```

LDSP1 MK;
  DB=MV

```

```

LDTMA;
  DB=ISTAT

```

```

LOOPK:ADD# ITOPS,KBIAS;
      SETMA

```

```

LDSP1 MKK;
  DB=MV-8.

```

```

DB-31.
INCTMA

FMUL TM,MD;INCTMA

FMUL TM,MD;
INCTMA

FMUL TM,MD;
INCTMA;
INCDPA

FMUL TM,MD;
INCTMA;
INCDPA;
FADD FM,DPX(0)

FMUL TM,MD;
INCTMA;
INCDPA;
FADD FM,DPX(0)

FMUL TM,MD;
INCTMA;
INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA

FMUL TM,MD;
INCTMA;
INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA;
DEC MKK

LOOPKK:FMUL TM,MD;
INCTMA;
INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA;
DEC MKK;
BGT LOOPKK

FMUL TM,MD;
INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA

FMUL;
INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA

FMUL;
INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA

INCDPA;
FADD FM,DPX(0);
DPX(-2)<FA

```



FADD;  
DPX(-2)<FA

INCDPA;  
DPX(-2)<FA;  
DEC MK

ADD MN1,KBIAS;  
BEQ STEP  
JMP LOOPK

STEP:LDDPA;  
DB=0  
LDSPI MK;  
DB=MV

SUB MN1,ITOPS

LOOPR:INCDPA;  
DEC MK

ADD MN1,ITOPS;  
SETMA;  
MI<DPX(-1);  
BGT LOOPR

NOP  
RETURN

\$END

```

DEFINE XSUM(ITOPS,M,AXJ,KBIAS)
LOCAL K,A,B
K=16
LOOP:K=K-1
A=ITOPS+K
B=AXJ+K
CALL SVE(A,M,B,KBIAS)
IF K>0 GOTO LOOP
END

```

```

DEFINE ZSUM(ITOPS,M,AZJ,KBIAS)
LOCAL K,A,B,L,C
K=16
L=KBIAS-M
C=15*KBIAS
A=ITOPS+C
LOOP:K=K-1
B=AZJ+K
CALL SVE(A,1,B,L)
A=A-KBIAS
IF K>0 GOTO LOOP
END

```

#### REFERENCES

- [1] R.S. Bucy, K.D. Senne "New Frontiers in Nonlinear Filtering"  
Lincoln Lab., Technical Note, 1978 - 16, Lexington, Mass.
- [2] R.S. Bucy, K.D. Senne, H. Youssef, "Pipeline Parallel and Serial  
Realizations of Phase Demodulators," Institute for Computer  
Applications in Science and Engineering, ICASE, Report #76-31,  
Nov. 1976, NASA Langley, Hampton, Virginia.
- [3] R.S. Bucy, C. Hecht, K.D. Senne, "New Methods for Nonlinear  
Filtering," Revue Francais d'Automatique, Informatique, Recherche  
Operationelle, J-1, 1973, 3-54.
- [4] R.S. Bucy, C. Hecht, and K.D. Senne, "An Engineer's Guide to  
Building Nonlinear Filters," Final Report SRL-TR-72-0004, Project  
7904, Frank J. Seiler Research Laboratory, USAF Academy, Colorado,  
(1972), DDC-AD-746921/2.



18 AFOSR

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM	
1. REPORT NUMBER AFOSR-74- USCAE 137/19 0923	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9	
4. TITLE (and Subtitle) 6 SOFTWARE FOR NONLINEAR FILTERING.	5. TYPE OF REPORT & PERIOD COVERED Interim Scientific Rpt. 1		
7. AUTHOR(s) R.S. Bucy, F. Ghovanlou A.J. Mallinckrodt, K.D. Senne	8. PERFORMING ORG. REPORT NUMBER USCAE-53-4514-1787, 53-4514-1792		
9. PERFORMING ORGANIZATION NAME AND ADDRESS University of Southern California Department of Aerospace Engineering Los Angeles, California 90007	10. CONTRACT OR GRANT NUMBER(s) F44620-76-C-0085 (Contract) AFOSR-76-3100 (Grant)		
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Office of Scientific Research Electronic and Solid State Sciences Division AFOSR/NA, Bolling AFB, Washington, D.C. 20332	12. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2305/B1 2304/A1		
13. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	14. REPORT DATE 11 Jun 1979		
15. DISTRIBUTION STATEMENT (of this Report) 12 135p.	16. NUMBER OF PAGES 129		
17. SECURITY CLASS. (of this report) UNCLASSIFIED		18. DECLASSIFICATION/DOWNGRADING SCHEDULE	
19. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) "The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies or endorsements, either expressed or implied, of the Air Force Office of Scientific Research of the U.S. Government."			
20. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) "This document has been approved for public release and sale; its distribution is unlimited."			
21. SUPPLEMENTARY NOTES			
22. KEY WORDS (Continue on reverse side if necessary and identify by block number) Software 7600 Demodulation Nonlinear Filtering 6600 Star 100 Illiac AP 120B Phase Lock Loop			
23. ABSTRACT (Continue on reverse side if necessary and identify by block number) As part of a continuing search for the ideal architecture for performing the computations required to realize a non-linear filter, we have developed software for various machines over the past ten years. A description of the latest software is given in [1], while [2], [3], and [4] are useful for for background information on the non-linear filtering problem as well as comments about software efficiencies relevant to various machines.			

(continued)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE(When Data Entered)

↖ We started our studies over 10 years ago using the CDC 6600 at the Aerospace Corporation and Kirkland AFB, and continuing at Eglin AFB, see [4]. At the Institute for Advanced Computation, we gained access to the Illiac IV and at ICASE, Nasa Langley, the Star 100, see [2]. Access to the Cray was obtained through Cray Research and later NCAR. Experiments on the AP120B array processor were possible because of the acquisition of one here at USC used in conjunction with a PDP 11-55. ↗

The purpose of this report is to document the current software, for all these machines. In particular, we have found [2], with the listings of the 6600 and Star Codes, extremely useful in the past, although now these listings are outdated. In particular, the assembly language coding for the AP-120B involved extensive effort over a long time period and should be documented so that others interested in similar problems, can avoid the pain of developing the software from scratch.

UNCLASSIFIED